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The European Science Notes Information Bulletin (ESNIB) is a compilation of reports on recent developments in European science of specific interest to the US R&D community, and is issued in support of the mission of the Office of Naval Research European Office. It is not intended to be part of the scientific literature. The value of the Bulletin to Americans is to call attention to current activity in European science and technology and to identify the institutions and people responsible for these efforts. ESNIB authors are primarily ONREUR staff members; other reports are prepared by or in cooperation with staff members of the USAF European Office of Aerospace Research and Development or the US Army Research, Development and Standardization Group. US scientists traveling in Europe may also be invited to submit reports.

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ESN INFORMATION BULLETIN

89-05

This publication is approved for official dissemination of technical and scientific information of interest to the Defense research community and the scientific community at large

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ACOUSTICS

BIOLOGICAL SCIENCES

COMPUTER SCIENCES

The overall structure, languages and tools, and programming for and of Helios, a true distributed software system are described. Helios uses the primitives provided by the transputer hardware such as process creation, process switching, timeslicing, and interprocess message passing as basic building blocks for an operating system designed to run on multiple processors.

ENGINEERING

Research in the Departments of Control Engineering, Applied Thermodynamics and Fluid Mechanics, and Turbomachinery is discussed. The author says that although these departments put much emphasis on applied research, significant contributions are also made at the fundamental level.

FLUID MECHANICS

The Norwegian Institute of Technology, located in Trondheim, is Norway's prime research center. This report concerns the work of NIT's Hydro and Gas Dynamics Division of the Mechanical Engineering Department, and two divisions of the Electrical Engineering Department.

The authors discuss Sir James Lighthill's presentation on the propulsion method of the rigid-bodied triggerfish. By splitting the principal three-dimensional problem of the propulsion method into two two-dimensional probems – rigid fin hinged on a rigid body and wavelike motion of a flexible fin – Sir James was able to satisfy the question of what triggers the triggerfish.

MATERIALS SCIENCE

This conference, which took place in October 1988 in Marbella, Spain, was held primarily to discuss the merits and potential applications of the new magnetostrictive material terfenol. The author says that terfenol, a most promising material, is still undergoing significant development, processing is still being characterized, and industry is not yet ready to produce it in volume.

Selected presentations given at this conference, which was held in Riva del Garda, Italy, are discussed. The topics are: fundamental ion-solid interactions, ion implantation of steels, ion-beam-assisted deposition, chemical effects, and applications and equipment.

MATHEMATICS

MECHANICS

PHYSICAL ELECTRONICS

PHYSICS

SUPERCONDUCTIVITY

NEWS, NOTES, AND ABSTRACTS

ACOUSTICS

Ship Dynamics and Vibrations at Brunel University

By David Feit. Dr. Feit is the Liaison Scientist for Acoustics and Mechanics in Europe and the Middle East for the Office of Naval Research European Office. He is on leave until January 1990 from the David Taylor Research Center, where he is a research scientist in the Ship Acoustics Department.

The UK's Brunel University is a small technical university located in Uxbridge, Middlesex, close to the western boundary of the greater London area. The university came into existence in 1966, when it was formed out of a technical school in London called Acton Technical College. The student body is relatively small – about 3000 – and the academic staff currently numbers 254.

Brunel is unique in the British educational system in that each undergraduate student is sponsored by an industrial firm which employs the student at its own facilities for a 6-month period each year during the student's first 3 years at university. The last year of study, just prior to graduation, is spent in residence at the university itself. This form of education, similar to "cooperative education" programs in the US, is referred to in the UK as a "thin sandwich program."

On a recent visit there, I was hosted by Professor of Applied Mechanics W.G. Price, who directs the Ship Vibration and Dynamics Group. This group is part of the Department of Mechanical Engineering, which is headed by Professor A.J. Reynolds. The department also has groups devoted to biomedical engineering, fluid mechanics, energy and environmental engineering, and structures and materials.

There are currently 12 Ph.D. candidates studying under the supervision of Price and his staff. Most, if not all, of these students are non-UK citizens, a trend very similar to the situation in US graduate engineering schools. Some of the work of two people in Price's group is discussed below.

Statistical Energy Analysis of Periodic Structures

A.J. Keane, a recent Ph.D. who, contrary to the trend mentioned above, happens to be a British citizen and a former naval architect with the Ministry of Defence, submitted a thesis in March 1988 dealing with the application of statistical energy analysis (SEA) to engineering structures. This thesis points out deficiencies in the standard formulation of SEA when it is used to study heavily damped structures, systems that are characterized by strongly coupled subsystems, and systems that have nonuniform frequency distributions. The example examined in detail is that of two point-coupled multimodal subsystems which happen to lend themselves to exact solution using classsical analysis.

Keane presents revised equations for the coupling loss factors for those cases where the damping is such that it does not introduce intermodal coupling, as is the case for "proportional damping." He handles strongly coupled subsystems by introducing a correction factor derived from the case of infinite coupling strength. This factor is combined with a measure of the transition between weakly and strongly coupled behavior to yield a new approximate correction factor to the coupling loss coefficients.

As an example of systems with nonuniform frequency distributions, Keane examines cases of almost periodic systems which are characterized by pass and stop bands. Such a system is then "randomized" and Monte-Carlo techniques used to determine the actual probability density function of the natural frequencies. SEA is then applied to this case, and the results are compared to the usual SEA formulation using a uniform probability density function for the natural frequencies for various values of the coupling strength. Based on this comparison the limitations of the traditional approach for such systems are then discussed.

Procedures for Calculating Viscous Forces on Submerged Bodies

A graduate student, Ph.D. candidate Mingyi Tan, is developing procedures for calculating the viscous forces generated on a steadily moving submerged two-dimensional body. The Navier- Stokes fluid equations of motion are reduced to the steady state, and if the fluid flow is considered to be a perturbation on the free stream velocity of the steadily moving body the resulting equations of motion reduce to the Oseen equation.

The solution to this equation for an arbitrarily shaped rigid body can be represented as an integral form by introducing the Green's function solution of the adjoint of Oseen's equation. By allowing the field point to move

onto the body boundary, an integral equation on the dependent variables is obtained in terms of known functions on the boundary, thereby reducing the dimensionality of the problem. The integral equation is solved using a boundary element formulation in which the unknown functions on the boundary are taken as piecewise, continuous polynomials over discrete portions of the boundary. The integral equation then leads to a linear set of algebraic equations on the unknown polynomial coefficients. The same approach can also be used to solve the nonlinear problem, but this requires a surface integration over the region of the wake, and the eventual solution of a nonlinear set of algebraic equations with all the difficulties that such sets entail. Mr. Tan is currently working out the solutions for some specific body shapes and will, I believe, include the nonlinear effects in the final version of his thesis.

Concluding Remarks

This particular group under the direction of Professor Price, although small in numbers, is doing first-class research in maritime engineering problems very much relevant to navy needs. In our conversations Price characterized the work of his group as fundamental research in maritime engineering based on rigorous analysis and theory.

The group's principal areas of research are in:

- The dynamics of rigid and flexible structures situated in seaways
- Hydroelasticity theory and fluid structure interaction phenomenon
- Wave-making and wave pattern calculations for surface and subsurface vehicles traveling in homogeneous and stratified fluids
- The use of computers and artificial intelligence in the design of ships
- SEA of coupled periodic structures
- The dynamics of "poorly identified structures."

Price has been at Brunel since 1982, and during this period the group has had more than 30 papers published in refereed journals. During my visit I was not informed of any experimental work being performed directly at the university but I was told that the analysis being performed has in some cases been compared to experimental results obtained elsewhere.

3/19/89

A Russian Monograph on Vibration Isolation

by David Feit.

Several prominent Russian acousticians attended the INTERNOISE 88 meeting held in Avignon, France during the period 28 August to 1 September 1988. (ESNIB 89-04-3[1989]).

One of these scientists, V.T. Lyapunov, who is well known for his work on vibration and noise control applied to maritime structures, is the coauthor, together with E.E. Lavendahl and S.A. Schlyapochnikov, of a monograph, *Rubber Vibroisolators*, currently available only in Russian, which was published by Sudostroennie in late 1988. This publishing house seems from my experience to be the major source of publications in the field of maritime engineering in the Soviet Union.

During the course of the meeting Dr. Lyapunov presented Gideon Maidanik (David Taylor Research Center) with a complimentary copy of his book. Maidanik, being aware of my position as ONR Liaison Scientist for Acoustics and Mechanics, asked me to look the book over to determine what I thought of its potential usefulness.

With only a smattering of knowledge in Russian, I have gone through the contents by reviewing the chapter headings, the equations, and the illustrations. The book, which is 213 pages long, is divided into 12 chapters and a number of appendices. The monograph seems to exhaustively cover all aspects of the field of vibroisolators – from the fundamentals of the viscoelastic material behavior of the rubber materials serving as the primary components of the isolators to a description of the geometry and construction of what appear to be currently used shipboard implementations.

A sample of the chapter titles, using my own translation is as follows:

- Chapter 1, Physical basis of vibroisolators
- Chapter 2, Stiffness of rubber vibroisolator elements under small deformation
- Chapter 3, Deformations and stiffness of vibroisolation elements under static loading
- Chapter 7, Transient loading of vibroisolation elements

- Chapter 10, Design and application of vibroisolators
- Chapter 11, Measurement of rubber parameters, necessary for calculation

The detailed analysis presented in the monograph gives evidence to the notion that in the Soviet Union a great deal of attention is paid to the design of isolators to fully exploit their potential in reducing structureborne noise and its concomitant sound radiation. To those readers with a knowledge of Russian, I believe this book will serve as an excellent survey of both the fundamentals and the application of vibroisolation as a tool in the control of noise and vibration. For those of us less proficient in Russian, I would strongly recommend that a translation of this book into English be obtained as soon as possible.

3/19/89

Acoustics at a Meeting of the London Mathematical Society

by David Feit.

The January meeting of the UK's London Mathematical Society devoted its attention to the subject of acoustics. The venue for the meeting, held on January 20, was Burlington House. The invited speakers were D.G. Crighton (University of Cambridge, UK) and F. Leppington (Imperial College of Science and Technology, London).

Crighton spoke on the subject of nonlinear acoustics. In his introductory, remarks he discussed the relative importance with which the subject seems to be viewed in the West as compared to the USSR. He estimated that at a recent US meeting there were about 150 attendees, while meetings on the same subject in the USSR have attracted as many as 2000 attendees. He said that there are at least three areas in which nonlinear acoustics are applicable. These are: the long-range propagation of shock waves generated by supersonic aircraft, the biomedical applications of intense shockwaves such as in lithotriptic devices where focused shock waves are used to disintegrate kidney stones, and in underwater parametric arrays. The latter are used to generate directive beams of very-low-frequency sound waves without requiring large arrays. Since he was speaking to an audience of mathematicians he concentrated on a discussion of the mathematical properties of solutions to various model equations for different types of nonlinearities. He discussed the unusual physical features of the solutions obtained principally by asymptotic analysis of mostly one-dimensional equations, and concluded by stressing the importance of such analyses as a precursor to numerical analyses for more complex situations.

The lecture by Leppington began with a very quick review of the linear version of acoustics and its interaction with moving surfaces. After presenting the equations governing the phenomena, he went on to discuss the method of matched asymptotic expansions (MAE). Giving graphic emphasis to his point by employing his flair for showmanship, he went from one end of the podium to the other to describe the different perspectives the analyst uses to describe a problem using MAE.

Having set the stage, he then went on to show how MAE is used for two specific problems. One involves the determination of the sound field radiated by a moving rigid sphere. The other deals with the analysis of a perforated honeycomb type of panel that might be effective as a noise transmission barrier. This is work that he is doing under contract with the Royal Aerospace Establishment at Farnborough. I expect to report on this particular work in more detail in a later report.

These talks, the only ones presented at this meeting, were meant to introduce mathematicians to the world of acoustics. In the work they presented, the two speakers provided excellent examples of the way modern advanced mathematical techniques can be used to solve realistic problems in acoustics. In the present age of the computer, where many such problems are often solved using computational techniques, the analytic approaches presented here provide welcome relief.

3/19/89

Aeronautical Research at Sweden's KTH and FFA

by Daniel J. Collins. Dr. Collins was the Liaison Scientist for Aeronautics in Europe and the Middle East for the Office of Naval Research European Office. He has returned to the Naval Postgraduate School where he is a Professor of Aeronautical Engineering.

The Royal Institute of Technology (KTH)

The Royal Institute of Technology (KTH), founded in 1825 in Stockholm, is the largest and oldest college of technology in Sweden. The institute has 7500 undergraduates and 1200 graduate students. The academic staff numbers 125 professors and 174 lecturers. There is a close relationship between KTH and the Aeronautical Research Institute of Sweden (FFA) and, in fact, one of the departments at KTH is run by people employed by the FFA. I will discuss the FFA and its department at KTH in the latter part of this article and will begin the research review with the Applied Mechanics and Vehicle Technology Section, which conducts fluid mechanic and aerodynamic research at KTH.

Professor F. Hjelte directs the Applied Mechanics and Vehicle Technology Section. The section has eight professors and a yearly student input of around 40. The four departments in the section are aeronautical engineering, hydrodynamics, gas dynamics, and mechanics. I would like to highlight the research activity in the departments of gas dynamics and mechanics. Although the word "department" is used in the English translation of the Swedish word to describe the subgroups of the section, the departments are really more comparable to the German academic institutes since one or two professors are involved in each department.

Gas Dynamics. The gas dynamics department consist of two units – an experimental unit directed by Dr. S. Berndt and a computational fluid mechanics (CFD) unit directed by Dr. L. Fuchs. Experimental equipment consists of two wind tunnels and two shock tubes. The two experimental and computational units complement each other in that the experimental activity is closely matched with numerical calculations. A two-color laser Doppler anenometer is used in flow measurements. My focus is on the CFD unit but I will also mention the associated experimental activity. Fuchs' unit has a typical institute structure in that he is assisted by a postdoctoral student, has seven doctoral students and four visiting scientists working with him. External finance is from the Swedish Board for Technical Development (STU) and from contracts with industry – one contract, for example, involving calculation of flows in hydroturbines and pumps. The two principle research axes are basic research in fluid mechanics and research in numerical flow simulations.

Two projects involving laminar flow of multistate systems are involved in the basic fluid mechanics research. Both numerical and experimental studies are underway: on the sudden expansion of a multistate systems in the first project, and, in the second project, on the flow of a multistate system between concentric cylinders in which the inner cylinder is rotating. Previous work in this area has concerned the numerical analysis of a sudden expansion for a single-state system using a time-space multigrid (MG) method for 2-D incompressible viscous flows with a Reynolds number of 300.

In numerical flow simulation, the department has four main areas of investigation: compressible flows, flows with combustion, physiological flows, and development of CFD methods. One of the strong points of the CFD unit is its work in the application and development of multigrid methods to various flow situations, which can include variable or moving geometry. Adaptive schemes, mainly based on manual methods, have been developed for the governing equations, for local mesh refinement, and for higher order discrete approximations. Recently, the conjugate residual method (Eguchi et al. 1988) was used in an application of the finite element method (FEM) to incompressible viscous flow analysis. By a combination of structured and unstructured grids, a considerable reduction of storage requirements was obtained. Also discussed was the use of an element-by-element preconditioner in order to accelerate convergence. One of the problems analyzed was that of a Karman vortex street.

Compressible flows involve transonic flows past airfoils and 3-D objects, gas turbine flows and air-intake, and duct flows. The CFD unit has some code development underway, and a recently reported algorithm consists of a coupled Euler solver and potential solver for transonic vortical flow (Fuchs, 1987). The resulting scheme is as accurate as the Euler solver but it requires less computational effort and less computer memory. Some commercial codes are being used in the calculation of gas turbine flows. This code (FIDIM) uses 200,000 nodes to characterize the flow and requires 4 to 5 hours of computing on a Sun work station. In the analysis of combustion flows, the unit relies to a certain extent on commercial codes. The CFD unit is also analyzing combustion with swirl – the main numerical activity being the development of a code with accelerating multigrids based on the TEACH code.

In physiological flows, the unit is conducting both experimental and numerical experiments. Their concern is

primarily with pulsating flows. In one case, the flow past artificial heart valves is being analyzed and measured. In a further experiment, flow in a bifurcating tube is being studied by LDA methods in order to be better understand arteriosclerosis. This latter project is in cooperation with the Georgia Institute of Technology (Atlanta) and a series of Swedish hospitals.

Mechanics. Professor P. H. Alfredsson, assisted by Dr. D. S. Hennigson, directs the studies of turbulence at KTH. There are two exciting developments in the unit. The first is an investigation of the possibility of drag reduction by outer layer manipulators in turbulent boundary layers. The experiment for this study was carried out in a 260-meter towing tank with large eddy breakup devices (LEBU) on a flat plate in a single and tandem configuration. The highest Reynolds number based on the chord was 260,000. Since in-flight drag measurements were made, the performance of the manipulator as well as the skin friction drag could be determined. Despite substantial skin friction reduction in certain configurations as well as having a low device drag , the significant result was that no overall drag reduction was found. Alfredsson and his coauthors (to appear in *Physics of Fluids*) conclude that substantial net drag reduction using LEBU is implausible.

The second development is concerned with the study and analysis of wave structure of turbulent spots in plane Poiseuille flow. The original experimental measurements of Henningson and Alfredsson have now been simulated numerically by Henningson, Spalart, and Kim (1987) at the Ames, Iowa facility on an XMP Cray with a computing time of 60 hours. Henningson has spent two summers working at the Ames research center. The agreement of the numerical calculations with the experimental results is fascinating. Alfredsson believes that the so-called bursting events are important to a fundamental understanding of turbulent structures and coherent structures associated with turbulence. Present work is directed at the development of an understanding of the internal structure of the turbulent spots.

Aeronautical Research Institute of Sweden

The Aeronautical Research Institute of Sweden, commonly called the FFA, is located in a suburb of Stockholm. The FFA has a fairly broad mandate to promote and advance aeronautics and aerospace in almost all aspects in Sweden. From an American viewpoint, one would have a tendency to think of NASA as a comparable organization. Such a comparison is, however, somewhat missleading since the FFA is a fairly small institute with a personnel level of about 260 people, of whom 102 are university graduates. Of the three division or departments in which research is done, I was primarily interested in the Aerodynamics Department, which has a staff of 104. The Structures Department (35 people) deals with composites, fatique and fracture, and computational mechanics. The other department, called the Technical Department (93 people), is involved with transducer and balance design, computer applications (including CAD/CAM), and electronics.

The Aerodynamics Department is directed by Dr. S. Lundgren, who is also the deputy director to Dr. L. B. Persson, Director General of FAA. Research is conducted in the principal fields of aeronautics including subsonic, transonic, and supersonic flows. There is also a strong flight safety program.

The aerodynamic facilities at FFA are excellent. In particular, the new (1988) computer-controlled transonic wind tunnel T1500, with a test section of 1.5x1.5 m, is one of the largest transonic tunnels I have seen in Europe. The Reynolds number of 12 million at Mach = 1 exceeds, as far as I know, all other European wind tunnels. The tunnel will be shortly operational and should provide an excellent facility for high-Reynolds-number testing. It is the high-Reynolds-number flows that present great difficulties in numerical simulations, and there is therefore a great need for testing at high Reynolds numbers. A large low-speed tunnel (90 m/s) with a diameter of 3.6 meters is also available for testing programs. Large-scale aircraft models can be tested on a sophisticated support system which has the capability of rotating the model around the spin-axis at 360 rpm. This tunnel is also used for the study of atmospheric effects on buildings such as off-shore structures. There are a series of other tunnels including a hypersonic 0.5-m-diameter tunnel with a Mach number range from 4 to 7. An interesting feature of some of these tunnels is the fact that they are "suck-down" rather that blow-down. In the granite rock below, the tunnels is a carved-out chamber which is evacuated to suck-down the tunnel exhaust.

Typical experimental work in the tunnel has involved determination of dynamic derivatives, flow field surveys based on a three-dimensional laser Doppler velocimeter, and boundary layer measurements. Boundary layer measurements have also been obtained in flight. Recent work has been on transition measurements on a cone in flight (Olsson, 1988). Transition from a laminar to turbulent boundary layer were measured in flight on a 10-degree cone flown on a SAAB 32 Lansen. No evidence of Tollmen-Schlichting waves were seen and the data correlated well with NASA flight tests.

About 20 people of the Aerodynamics Department are located at KTH in Stockholm. This group is directed by T. Jannsson and has two activities. The first is based on the low-speed tunnel (1.5x1.5 m) located at KTH and involves many of the same activities as the larger low-speed tunnel at FFA, although perhaps take-off and landing performance of aircraft is more closely studied at KTH. The other activity is based on a research flight simulator

called FOSIM. The simulator is a moving-cockpit, three-degree-of-freedom simulator. Some simulator projects have included autopilot design and flight control systems. Present emphasis is on handling qualities.

Conclusions

The turbulence research at KTH is of fundamental importance to an understanding of turbulent structures. This work is perhaps the most significant experimental and numerical work in turbulence that I have encountered in Europe. The numerical comparisons with the experimental results are the key to understanding turbulent structures. This work is an important step in the direction of the development of the ability to calculate turbulent structures. Excellent work is also being conducted at KTH in multigrid methods.

The FFA has some of the best wind tunnel facilities that I have visited in Europe. Much of their work is for the military and as such the results are not readily available in the open literature. The applied nature of work at FFA is clearly evident. There appears to be a very favorable interaction with KTH – some of the professors at KTH sitting on the board of directors of FFA. I was encouraged during my visits to look on KTH and FFA as in some sense a joint organization in the area of aeronautics and aerospace. From this viewpoint, Sweden has a very strong effort in aeronautics.

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2/6/89

BIOLOGICAL SCIENCES

Biotechnology at the Technical University of Hamburg-Harburg

by Claire E. Zomzely-Neurath. Dr. Zomzely-Neurath is the Liaison Scientist for Biochemistry, Neurosciences, and Molecular Biology in Europe and the Middle East for the Office of Naval Research European Office. She is on leave until July 1989 from her position as Director of Research, the Queen's Medical Center, Honolulu, Hawaii, and Professor of Biochemistry, University of Hawaii School of Medicine.

The Technical University of Hamburg-Harburg (TUHH), West Germany, was founded in 1978. Initially, the buildings were located in converted factory buildings. However, construction of a new facility was initiated a couple of years ago and is expected to be completed within 18 months. Some of the departments are already in operation in the new buildings.

An essential motive for the foundation of the TUHH was the expectation that a general strengthening of the technical and scientific competence of the region would emanate from the TUHH which would be reflected qualitatively and quantitatively in job creation. The fundamental idea results from:

- A shortage in Germany's northern region of high-performance establishments undertaking research and development in the engineering sciences
- A high concentration of medium-size and small firms in the urban area of Hamburg without research and development establishments of their own
- The necessity of providing job security by offering sophisticated technology for small and medium-size firms
- The lack of university spaces in the sciences of engineering in the northernmost part of West Germany, with the consequence that it is more difficult to find qualified junior engineering staff there than in the southern part of the country
- A novel concept of interdisciplinary research.

In order to attain these aims, close interaction between the TUHH and the region of Hamburg, in particular, was necessary. On the one hand appropriate contacts were made through important committees of the technical university (foundation senate, appointment committees) in which representatives of industry, trade unions, authorities, and other universities took part. On the other hand, the TUHH offers directly its know-how to potential users and other interested parties. That is the reason why the TUHH has appointed a Technology Mediator to encourage close contact between technological demand and technology supply, especially for small and medium-sized firms. Moreover, the Hamburg Institute of Technology Advancement has employed a consultant for the founding of small firms who support the organization of technically based, small companies by assisting them with advice and practical help if, in spite of having good product ideas, the engineer or technician who intends to set up on his own is not capable of estimating the risk of founding a new enterprise.

The TUHH receives substantial financial support from both the federal government and the state of Hamburg not only for the contruction for the new campus but also for support of personnel and equipping of the research laboratories. The TUHH was the first technical university in West Germany to offer a degree in bioengineering. The only other technical university offering this program is in Stuttgart. (However, bioengineering degrees are also planned for the technical universities in Berlin and Munich.)

The TUHH is divided into six research areas and four teaching departments. Whereas study courses necessarily have to be organized according to subjects, research at TUHH is organized on an interdisciplinary basis; i.e., scientists from different branches of study collaborate in the respective research areas. The fundamental idea is derived from the fact that there is scarcely a technical device or engineering plant whose development does not involve several different fields of knowledge. Because a scientist may work on several research projects, generally in more than one research area, a degree of flexibility can be achieved which is important for successful research in view of today's increasingly rapid changes in technology.

The six research areas at the TUHH are:

1. Systems planning, manufacture of apparatus, and production engineering as well as appropriate operational research for industrial process engineering (measurement and automatic control systems)

2. Material physics, including materials research and polymer and composite plastics as well as mechanical design engineering

3. Safety engineering, reliability engineering, (aspects of) work protection and environmental protection technology (monitoring, control, and transmission systems)

4. Hydraulic engineering, ocean technology, and corresponding biotechnology. (There are two divisions in biotechnology: Biotechnology Section I (bioprocess and biochemical engineering) and Biotechnology Section II (biotransformation and biosensors.)

5. Building construction

6. Urban renovation and maintenance.

In this report, I will present only the research being carried out in the two biotechnology sections at TUHH where I met with scientists engaged in biotechnology research on a liaison visit. However, I have also included information on some research related to biotechnology and which is being carried out at the Chemical Engineering Section at the TUHH.

Biotechnology Section I

H. Maerkl, formerly at the Technical University of Munich, is head of this section. The research of Maerkl and his coworkers is concerned with bioprocess and biochemical engineering. Maerkl was involved in setting up the program for a degree in bioengineering at the TUHH, the first at a technical university in West Germany. He and his group also work closely with the researchers in Biotechnology Section II. In the area of process engineering, Maerkl and coworkers are involved in the following studies: (1) mass culture of microalgae and photosynthesis, (2) anaerobic digestion, (3) production of erythromycin, and (4) cultivation of mammalian cells. Another research area under investigation is concerned with biological reactors including membrane bioreactors, cell culture systems, and biogas reactors. The third main area of research deals with bioprocess control such as control by computers, mathematical modeling, and observer structures.

Maerkl and coworkers have already developed a membrane bioreactor which is being marketed by Bioengineering AG, Wald, Switzerland. In collaboration with H. Thamer, Maerkl and his group have also developed a novel type of biogas reactor, the Tower Type Biogas Reactor. This biorector permits large reactor heights. Biogas is removed by means of modular installations. By controlling the flow rate of biogas, the sedimentation and the mixing behavior of the reactor can be adjusted. The aim is to achieve optimal reactor performance for each substrate. Maerkl informed me that this reactor will probably also be marketed by Bioengineering AG of Switzerland.

Maerkl and his group are also studying hydrodynamic stress of microorganisms. Maerkl said that the production of microbial metabolites and the growth of microorganisms are affected by mechanical forces, such as occur on stirring, pumping, and aeration in industrial equipment. These investigators have found that the sensitivity

of the organisms depends upon the stability of the cell wall and upon its morphology. Raising the viscosity of nutrient solution increases the symptoms of damage at a given stirrer speed. In the case of methane-producing microorgansisms, growth and product formation (methane production) are affected in the same manner. Physiological stress, induced, for example, by the absence of essential nutrients, proves additive to mechanical stress in its effect. Maerkl thinks that the power dissipation per unit volume should be taken as a guide on scale-up or on transfer of experience gained with one kind of flow system (jet flow, for instance) to another (such as a stirred tank).

Biotechnology Section II

This section is headed by V. Kasche. He and his group are involved in many areas of biotechnology research. The fields of research under investigation are:

- Enzyme-catalyzed synthesis of condensation products (peptides, beta-lactam antibiotics) with free and immobilized biocatalysts
- Analysis with immobilized biocatalysts (biosensors)
- Production, putification and characterization of hydrolytic enzymes
- Biocatalyst stability
- Development of apparatus for on-line analysis of enzyme (bio)-reactors with high-performance liquid chromatography
- Animal cell cultures in biotechnology
- Microbial degradation of xenobiotics in soil
- Risk assessment for genetically engineered soil bacteria.

Kasche and his coworkers deal essentially with the preparative biotransformation and analytical (biosensors) application of enzymes (isolated or in living cells) in biotechnology.

In the preparative area, at present, these researchers are investigating free and immobilized hydrolytic enzymes as biocatalysts for the synthesis of condensation products (among others beta-lactam antibiotics such as penicillin, peptides, etc.). In this respect, they are examining:

- Methods for optimization of microbial stem cell development and enzyme production and development
- Organization of enzyme-technical processes
- Methods for improved enzyme stabilization under the respective conditions of application
- Methods for improved characterization of applied enzymes
- Ways to improve the understanding of the mechanism and kinetics of enzyme-catalyzed reactions.

In the analytical area, the following projects are in progress: (1) chromatography (affinity chromatography and automation of specimen preparation) and (2) the application of various enzymes for the development of fluorescence-based fiberoptic biosensors for which the production/application of suitable antibodies is required.

Kasche and colleagues are also examining enzyme systems in microorganisms which contribute to microbial waste degradation in the soil. In this project, these researchers are also looking for new enzyme activities of biotechnological significance.

Kasche and his group have examined the mechanism of the kinetic-controlled enzyme-catalyzed synthesis of beta-lactam antibiotics and the factors which decisively influence the production yield with the aim of optimizing the yield by these biotechnological syntheses. These researchers have observed maximal product concentrations (kinetically-controlled maxima) which are much greater than the thermodynamic equilibrium concentrations. These maxima are suitable end points for the biotechnological syntheses of the beta-lactam antibiotics. The influence of the following factors on the synthesis of Ampicillin and Cephalexin have been studied: (1) mode of side chain activation (amide, ester) and nucleophile (6-aminopenicllinic acid, or 7-aminodesacetocephalosporin acid); (2) enzyme source and immobilization (*E. coli*, *Xanthomonas citri*); and (3) ion strength, temperature, and pH. The mechanism and expression for the optimization of the maximal yield was derived from the data yielded by the above studies. For this work, many enzyme activities were determined using high-pressure liquid chromatography (HPLC), for which it was necessary to develop an on-line analysis system (automatic dilution and injection). This made possible the rational optimization of the yield.

Kasche said that the demand for peptides for therapeutic purposes and for nutrition and feed addtion will increase. These can be produced biotechnologically and chemically. For this particular project, Kasche and his group are examining how the yield can be influenced by the biotechnical (enzyme-catalyzed) peptide synthesis by factors such as the sequence and stereospecificity of the enzyme used as well as the solvent.

Kasche and colleagues are also preparing polyclonal and monoclonal antibodies for their studies. They have prepared polyclonal and monoclonal antibodies for the enzyme penicillin amidase produced by *E. coli*. These researchers produce monoclonal antibodies in bioreactors for animal cells in order to produce large amounts of the antibodies.

Extensive studies are also being carried out by Kasche and coworkers on the development of various types of biosensors using immobilized enzyme or antibody systems (immunosensor). The reaction of the substance to be examined (for example, penicillin, amino acids) with an immobilized enzyme leads according to the substance concentration to a pH change which in turn initiates a

change in fluorescence of an (also immobilized) fluorochrome. The reaction of the substance with the immobilized enzyme system results in a bioluminescence signal which is proportional to the substance concentration. In the antigen-antibody sensor (immunosensor), the substance causes a change in the equilibrium, corresponding to its concentration in the system (fluorochrome label), which leads to a change in fluorescence.

According to Kasche, gene technology methods are assuming increasing importance for industrial use. Therefore, he and his group are also engaged in studies to utilize biotechnically the procedure of spontaneous amplification of chromosomal DNA sequences. They are stabilizing introduced genes in an amplifiable region of the chromosomes thereby increasing to a multiple of the copy number. Kasche said that this technique offers two advantages as compared with the usual use of multicopy plasmids: (1) the heterologous DNA is more stably established in the organism and (2) the establishment of a multicopy number for the introduced gene takes place spontaneously, eliminating the use of antibiotic-resistant genes.

Chemical Engineering Section II

G. Brunner is head of this section at the TUHH. The research activities of Brunner and colleagues encompass the use of compressed gases for the separation and conversion of substances, and investigation of membrane processes – primarily fouling of membranes in ultrafiltration processes. The following is a list of research activities:

- Separation of organic substances from aqueous solutions (for example, ethanol-water)
- Extraction of natural substances from solid material
- Chromatographic separations with supercritical gases
- Behavior of natural substances (especially oil seeds) under pressure and at changes in pressure
- Substitution of liquid solvents by compressed gases in chemical and biotechnological processes
- Mass transfer at the supercritical fluid extraction of solid materials
- Heat and mass transfer at the condensation and vaporization of mixtures of hydrogen, water vapor, and hydrocarbons
- Heat and mass transfer in vessels under pressure
- Phase equilibria at elevated pressures (maximum 1000 bar) and temperatures up to 500°C in multicomponent systems
- Conversion of natural substances (wood, oil, shale) under hydrogenating conditions

Many of the above research activities as well as the investigation of membrane fouling are important in biotechnological processes.

With respect to the use of compressed supercritical gases as solvents in separation processes, Brunner told me that this method promised certain advantages which can more than outweigh the disadvantages of higher investment costs. The advantages are: (1) products without contaminating components can be produced, since by reduction of pressure to normal level a complete separation of the gaseous solvent from the product is achieved, (2) solvents with favorable properties are available, and (3) pressure is an additional process parameter, by which operation and result of a process can be controlled in a simple manner.

Brunner and his group have been concerned since 1982 with the application of compressed supercritical gases to separate processes and chemical reactions. They are investigating the extraction of natural substances from solids, continuous countercurrent separation and pyrolysis, phase equilibria, and transport processes as well as the feeding of solids into pressure vessels.

Brunner also said that in mass separation with supercritical gases (gas extraction), the solvent power of dense gases has aroused considerable interest for technical processes. A great number of gaseous solvents are available, especially if solvent mixtures are included. These solvents can be used in one-stage or multiple-stage processes, running batchwise or continuously in countercurrent processes. Design of the equipment and simulation of the process requires correlation of the underlying phase equilibria. Brunner said that remarkable progress has been achieved in this field. Several companies already supply turnkey plants or specialized equipment from laboratory- to pilot-scale. Commercial plants are using extracted natural products and mineral oil residue processing.

Conclusion

Although the construction of the new TUHH buildings is not as yet finished, the facilities and equipment in the completed buildings as well as in the temporary buildings is excellent. As presented in my summary report on biotechnology in Europe and the Middle East (to be published in ESNIB), the German government has continued its policy of substantial support for biotechnology in the founding of the TUHH. The research being carried out in biotechnology at the TUHH as shown in this report is top quality even though the TUHH is a very new technical university. Present plans include an increase of 200 staff scientists within the next 3 years which will undoubtedly result in a large expansion of research activities not only in the biotechnology area but in the other technical areas of research at the TUHH.

3/19/89

Biological Sciences: University of Hamburg, West Germany

by Claire E. Zomzely-Neurath.

The main bioscience and biomedical facilities of West Germany's University of Hamburg are located in Eppendorf, a suburb of Hamburg but incorporated within the city of Hamburg. The university hospital is also located within the vast complex of the University of Hamburg-Eppendorf. The complex contains many old buildings as well as those newly built. However, the old buildings have been remodeled and laboratory facilities and equipment are excellent.

In this report, the research of a few scientists with whom I visited during a liaison trip to Hamburg is presented.

Cell Biochemistry and Neurobiology

D. Richter is head of the Institute for Cell Biology and Neurobiology, Faculty of Medicine, University Clinic Eppendorf. I met with his chief assistant, H. Schmale, as Richter was unfortunately ill. The research areas under investigation at the institute are as follows:

- Cell biology and clinical neurobiology
- Structure and function of neural membrane proteins
- Neural development and regeneration
- Neural signalling
- Molecular neuroanatomy

More specifically, Richter and Schmale are investigating the molecular mechanisms of diabetes insipidus, structural analysis of the gene for the neural peptide hormones (oxytocin and vasopressin), DNA-sequencing, cloning, and regulation of the expression of these neuropeptide hormones *in vivo*.

Richter and Schmale are well-known, particularly for their research on the neuropeptide hormones, vasopressin and oxytocin. Although these hormones have been under investigation for several years by many scientists, Richter and Schmale have made important contributions to the studies.

Vaopressin and oxytocin are nonapeptide hormones synthesized in the magnocellular neurons of the hypothalamus. Except for two amino acids, both peptides are identical in their sequences, with the C-terminal residues being amidated. Because of their structural relationship, they can be considered to be members of a common hormone family of the hypothalamus although their functions are quite distinct. Vasopressin controls water retention in the kidney while oxytocin regulates uterus contraction during birth and milk ejection. Besides their hormonal functions, the two nonapeptides appear to be involved in many other processes, such as learning and memory; reponses to tolerance development and physical dependency on alcohol, opiate, or heroin addiction; response to rewarded behavior; cardiovascular regulation; control of body temperature; and brain development. Both hormones are expressed predominantly in the same hypothalamic areas – for example, the supraoptic nucleus (SON) and the paraventricular nucleus (PVN) – yet there is no evidence that the two nonapeptides are present in one and the same hypothalamic neuron. Today, the structure of vasopressin and oxytocin precursors and their corresponding genes from a number of vertebrates have been elucidated. Despite their obvious sequence homology, the two hormones are the products of independent genes that evolved divergently away from a common ancestral precursor some 400 million years ago.

Some of the contributions by Richter, and Schmale and their coworkers to our knowledge about vasopressin and oxytocin include:

- Immunological identification of a common precursor to arginine vasopressin and neurophysin II synthesized by *in vitro* translation of bovine hypothalamic messenger RNA (mRNA)
- Nucleotide sequence of cloned complementary DNA (cDNA) encoding bovine arginine vasopressin-neurophysin II precursor
- Structural organization of the rat gene for the arginine vasopressin-neurophysin precursor
- Expression of the vasopressin and oxytocin genes in human hypothalami
- Precursor structure, synthesis, and regulation of vasopressin and oxytocin
- Structure and comparison of the oxytocin and vasopressin genes from rat
- Differential responses to osmotic stress of vasopressin-neurophysin mRNA in hypothalamic nuclei
- Expression of a mutant vasopressin gene: differential polyadenylation and read-through of the 3'mRNA end in a frameshift mutant
- The thymus as a neuroendocrine organ: synthesis of vasopressin and oxytocin in human thymic epithelium
- Single base deletetion in the vasopressin gene as the cause of diabetes insipidus in the mutant Brattleboro rats
- The mutant vasopressin gene from diabetes insipidus (Brattleboro) rats is transcribed but the message is not efficiently translated
- Brattleboro rat hypothalamic neurons transcribe vasopressin gene: evidence from *in situ* hybridization

- Immunocytochemical staining of supraoptic neurons from homozygous Brattleboro rats by use of antibodies against two domains of the mutated vasopressin precursor
- Expression of the oxytocin gene in the large cells of the bovine corpus luteum
- A single rat genomic DNA fragment encodes both the oxytocin and vasopressin genes separated by 11 kilobases and oriented in opposite transcriptional directions
- Functional expression of the oxytocin receptor in *Xenopus laevis* (frog) oocytes primed with mRNA from bovine endimetrium

Muscle Cell Differentiation

For the past few years, H. H. Arnold and coworkers, Department of Toxicology, Medical School, have been investigating the differentiation of muscle cells and have contributed important information to this field of research. Arnold considers that the differentiation of muscle cells is an excellent model system for studying tissue-specific gene regulation since the morphological transition from myoblastic precursor cells to differentiated myotubes is accompanied by the accumulation of newly synthesized contractile proteins and their corresponding messenger RNAs (mRNA). Heterokaryon experiments have demonstrated the involvement of diffusable, transactivating factors in the regulation of muscle gene expression. Understanding the mechanisms which determine the cell-specific activation of muscle gene promoters requires therefore the elucidation of interactions of cellular factors with gene sequences governing cell type-expression. Binding properties of trans-acting factors have been determined in numerous instances. However, only a few studies have demonstrated the functional relevance of these interactions in reconstituted *in vitro* transcription assays. Recently, Arnold and his group have demonstrated by nuclear microinjection that a fragment of the chicken cardiac myosin light chain 2-A promoter extending from nucleotides -135 to +25 is sufficient to confer myotube-specific expression. These investigators also showed that the distal sequence of this fragment sepcifically binds to nuclear factors. The functional significance of this factor-DNA interaction was illustrated by *in vivo* competition with protein-binding oligonucleotides which leads to the effective inhibition of the myosin light-chain 2-A promoter activity in the expressing cells.

Myosin is one of the main components of contractile structures in all muscle and nonmuscle cells. It consists of two heavy chains (220 kilodaltons (kDA) associated with two phosphorylatable or regulatory light chains (17 to 20 kDA) and two alkali light chains (16 to 21 kDA). It has been shown that multiple isoforms for myosin heavy chain and myosin light chain (MLC) exist. They are frequently expressed in a tissue- and developmental stage-specific manner. Their specific physiological role, however, is largely unknown. In order to investigate the molecular mechanisms involved in the adaptation of MLC patterns in different physiological or pathological situations, Arnold and his group first studied the alkali myosin light chains (AMLC) in the skeletal muscle of a 22-week-old human fetus by molecular cloning techniques. They have performed the complete nucleotide sequences and their corresponding amino acid sequences of complementary DNA (cDNA) clones coding for human MLC1 and MLC3 subunits, which represent the predominantly expressed isoforms at this stage of human development.

Arnold and his group also found evidence for the coexpression of other structurally related mRNAs in the same tissue. By isolation of the respective cDNA clones, partial sequence analysis, and hybridization to RNA, these researchers have identified a "putative" embryonic MLC that is also expressed in fetal ventricle and adult atrium. Another type of MLC cDNA was found that appears related to smooth and nonmuscle MLCs according to its pattern of mRNA expression and the hypothetically deduced amino acid sequence derived from a cDNA clone.

In mammalian organisms, the regulatory or phosphorylatable myosin light chains in heart and slow skeletal muscle have been shown to be identical and presumably constitute the product of a single gene. Arnold and coworkers analyzed the expression of the avian cardiac muscle light chain (MLC) 2-A in heart and slow skeletal muscle by a combination of experimental approaches – for example, two-dimensional gel electrophoresis of the protein and hybridization of mRNA to specific MLC 2-A sequences cloned from chicken. Their results showed that, unlike in mammals, in avian organisms the phosphorylatable myosin light chains from heart and slow skeletal muscle are distinct proteins and therefore products of different genes. According to Arnold, the expression of MLC 2-A is restricted to the myocardium and no evidence was found that it is shared with slow skeletal muscle.

Arnold and his group have also recently shown that the promoter of the chicken cardiac myosin light chain 2 gene shows cell-specific expression in primary cultures of chicken muscle.

These investigators have also recently found a novel human myosin alkali light chain that is developmetally regulated. They carried out a complete nucleotide sequence analysis of the complete cDNA (GT14), and the derived protein sequence constitutes the first structural information on this myosin isoform of any organism. Expression of this novel myosin was studied in fetal cardiac and skeletal muscle and in adult atria.

Some other recent studies by Arnold and his group include (1) a quantitative evaluation of promoter activity by microinjection of chloramphenicol acetyltransferase hybrid genes into tissue culture cells, and (2) the down-regulation of the chicken beta actin during myogenic differentiation with results showing that this does not require the gene promoter but involves the 3′ end of the gene.

The studies described above represent only some of the excellent research carried out by Arnold and his coworkers and show clearly that they are a very productive research group.

Cell Pathology and Diagnostic Techniques

M. Dietel is head of the research program at the Pathology Institute. The research carried out at the institute is concerned with biotransformation, cell pathology, and cancer research as well as development of diagnostic methods. Dietel and his colleagues work closely with physicians at the university hospital. These researchers are also responsible for developing methods to aid in the diagnosis of tumors. One interesting project which is presently undergoing further evaluation is the use of tissue cultures of various tumors to aid the physicians in deciding upon the type of chemotherapy to be used in the treatment of patients with cancer. I was told that they have developed an assay system using tissue culture methods which can predict which kind of chemotherapeutic agent would be the most effective. G. Arps, one of Dietel's assistants, said that some patients may be resistant to one type of chemotherapy whereas another type would be effective. Generally, this cannot be predicted in advance by the attending physician. However, their assay method, in which the tumor cells from a specific patient can be cultured, will show which will be the most effective chemotherapeutic agent for the particular patient. The assay method has not as yet been published or reported at any meeting because Dietel and coworkers think that there will be a great demand for this type of assay and they have to increase their personnel to take care of this demand. They expect this to take place shortly and then the method will be made public.

Conclusion

Although this report, due to time limitation, constitutes only a fraction of the excellent research in bioscience being carried out at the University of Hamburg, it is clear that, even with relatively small groups, the scientists at the University of Hamburg are carrying out first-class research.

3/19/89

8th International Biotechnology Symposium: Paris, France

by Claire E. Zomzely-Neurath.

Introduction

The 8th International Biotechnology Symposium, sponsored by the European Federation of Biotechnology in conjunction with the French Society of Microbiology under the auspices of the International Union of Pure and Applied Chemistry took place at the Congress Palace in Paris, France. This biotechnology meeting attracted about 1600 scientists from 57 different countries. Compared with previous biotechnology meetings held in Europe, there was a fairly large attendance by scientists from Eastern European countries as well as the USSR. The distribution of participants from academia and industry was 60/40 percent.

The extensive scientific program consisting of 21 sessions dealt with the following topics:

- Basic microbiology
- Genetics of animal cells
- Genetics of microorganisms
- Cell culture
- Protein design
- Enzymes and organelles
- Mass transfer and bioprocess kinetics
- Bioreactor technology and control
- Downstream processing
- Production of physiologically active molecules in heterologous systems
- Vaccines
- Biological reagents
- Recent progress in food and feed technology
- Plant biotechnology and its impact on agriculture

- New developments in the production of industrial chemicals
- Biohydrometallurgy
- Environment and waste treatment
- Patents, economic problems
- Safety
- Education
- Biotechnology in developing countries

In addition to the above lecture sessions, there were also several hundred poster presentations related to the topics covered in the sessions as well as several round table discussion groups. The exhibition area included exhibits of equipment and supplies by 73 organizations from 10 different countries.

Since there were an enormous number of presentations in concurrent sessions, it is only possible to present summaries of a few selected topics in this report. Biotechnology research in Europe is emphasized. The Proceedings of the 8th International Biotechnology Symposium are available from the French Microbiology Society, 28 rue de Docteur Roux, 75724, Paris Cedex 15, France.

Genetics of Animal Cells

P. Chambon (CNRS and U. 184/INSERM, Institute of Biological Chemistry, Strasbourg, France) gave an excellent presentation of the research being carried out by him and his group on constitutive transcriptional enhancers. Chambon discussed the work currently perfomed in his laboratory on the SV40 enhancer and its complete trans-acting factors and on the inducible enhancer factors which belong to the nuclear receptor multigene family (for example, estrogen receptors, progesterone receptors, and retinoid receptors). Chambon also presented evidence that yeast trans-acting transcriptional factors (for example, GAL4, GCN4) stimulate transcription in HeLa cells from several class B (II) eukaryotic promoters containing the cognate UAS. Chambon also described the use of chimeric proteins made up of DNA-binding domains and transcriptional activating regions coming from either yeast or nuclear receptor transactivators, to characterize the multiple functional domains responsible for the inducible enhancer activity of nuclear recptors.

Another scientist of international renown, P. Kourilsky (Unit of Molecular Biology of the Gene, U. 277 INSERM, UAC 115 CNRS, Institut Pasteur, Paris, France) spoke about genetics in the immune system and the role of the major transplantation antigens. Kourilsky said that presentation of antigen to T-cells by class I and class II major histocompatible (MHC) molecules is now known, and in most cases, involves peptides derived from the processed antigen rather than antigen per se. MHC molecules thus appear to be peptide receptors with a spectrum of specificities depending on their structure, and variable in relation to MHC polymorphism. Kourilsky discussed the following points:

(1) MHC molecules are not all polymorphic. Kourilsky and coworkers have identified a poorly polymorphic, quasi-ubiquitously expressed mouse class I H-2 gene encoding a new surface molecule associated with $\beta_{2\text{-m}}$.

(2) Kourilsky had earlier proposed that peptides derived from self proteins are presented as well. This hypothesis distinguishes (according to Kourilsky) between the somatic self and the immunological self and has numerous implications in various fields (immune surveillance, autoimmunity, and transplantation as well as ontogeny of the immune system). Kourilsky and coworkers have performed sequence analysis making use of the available data banks, and the results are compatible with the above hypothesis.

(3) Kourilsky and colleagues have produced chimeric antigens made with the $K\alpha$ and $D\alpha$ complementary DNA (cDNA) sequences. They have been expressed in mouse L cells, serotyped and tested for peptide presentation to specific CTL clones. These studies showed that a region critical for $K\alpha$ specificity in this system involves at least one of the residues 152, 155, 156. These investigators also found that the same residues are important for the recognition of the $K\alpha$-specific alloreactive CTL clones. Kourilsky said that these data are compatible with an interpretation of alloreactivity involving, in at least some cases, cross-reactions with presented self peptides.

Genetics of Microorganisms

The work in cloning and manipulation of antibiotic biosynthesis genes in *Streptomyces* by D.A. Hopwood and his group (John Innes Institute and AFRC Institute of Plant Science Research, Norwich, UK) was presented by Hopwood in a very interesting report. Sets of genes controlling the biosynthesis of antibiotics were isolated from *Streptomyces* strains by several different strategies. In all the cases analyzed, some or all of each biosynthetic pathway were located in clusters, which also included genes that confer resistance to the antibiotic as well as genes that regulate the expression of the structural genes. Hopwood said that understanding of these regulatory mechanisms will lead to rational approaches to optimizing antibiotic production, and interspecific transfer of structural genes between the producers of different antibiotics can lead to the production of novel "hybrid" antibiotics.

He said that in the biosynthesis of the polyketide antibiotics (which include isochromanequinones, anthracyclines, tetracyclines, macrolides, polyethers, and many other types of antibiotics), multifunctional synthases catalyze iterated condensation of thio-esters derived from acetate, propionate, or butyrate to yield carbon chains of varying length and carrying different side groups. The genes for the different polyketide synthases have varying

degrees of conserved DNA sequence homology so that genes for one antibiotic (for example, actinorhodin of *Streptomyces coelicolor*, A3) can be used as DNA hybridization probes to isolate other synthase genes. Hopwood and his group have isolated several genes which are being sequenced. According to Hopwood, the resulting information and studies of the proteins produced by over-expression of the genes, should help in understanding the mechanisms that determine the chain length and order of condensation of acyl units in the biosynthesis of different polyketides. These approaches should also lead to the rational design of "hybrid" synthases capable of producing novel polyketides.

Cell Culture

W. Scheirer (Sandoz Research Institute GmbH, Vienna, Austria) presented an informative lecture on animal cell immobilization. Scheirer said that many problems which occur in work with cultivated animal cells cannot be solved by the conventional methods of cell culture. These problems may be caused by the extreme fragility of animal cells, by some instability of the cell line, by very low-level secretion of the desired product or by the inconveniences inherent in the use of serum-supplemented media. One way to overcome some of these problems is immobilization. There are many publications on a large variety of immobilization systems. They may be distinguished by the goals of the immobilization:

- The protection of the cells from mechanical or biological stress
- The concentration or collection of the product
- Influencing biological parameters, for example, stability, secretion rates, etc.
- Influencing the product composition, for example, exclusion of medium components
- Influencing the technological features, for example, providing surfaces for adherence or stimulating signals
- Facilitating the separation of cells.

There are also technical approaches in dealing with animal cells such as:

- The encapsulation of one or more cells within membranes which may have many different characteristics
- The harboring of cells within porous matrices
- The attachment of cells to surfaces for allowing the spread of cells, which is frequently necessary for distinct cellular functions
- The loading of cells with particles for getting new characteristics – for example, allowing immobilization methods by magnetism or gravity.

Schreier said that the analysis of the detailed aspects of immobilization systems may lead to a rational process optimization.

Protein Design

Research in this relatively new area of biotechnology is expanding rapidly with many more laboratories now engaged in research in this area. K. Wüthrich (Institute for Molecular Biology and Biophysics, ETH-Hönggerberg [Zurich], Switzerland) and his group have been carrying out research on protein structure determination by nuclear magnetic resonance (NMR) in solution. In the past, three-dimensional protein structures could be determined exclusively using x-ray diffraction in single crystals. Wüthrich said that a new method he and his group developed offers a second method for determination of protein structure. This technique utilizes NMR in conjunction with suitable mathematical procedures, notably distance geometry, for the structural interpretation of the NMR parameters of proteins and ucleic acids. Wuthrich said that since NMR can be used for protein structure determination in solution and other non-crystalline environments, it provides complementary data to those from crystallographic studies. He thinks that the NMR method promises to become particularly attractive as a fast, efficient method for serial investigations of small homologous proteins. Wüthrich described the NMR method for protein structure determination in solution. He stressed the potential of the method for three-dimensional structure elucidation, as well as its use for checks on the purity of protein preparations, the amino acid composition and the amino acid sequence, all of which are of practical interest with regard to product control in protein engineering.

An excellent talk on x-ray analysis, protein structure, and the design of novel molecules was presented by T. L. Blundell (Laboratory of Molecular Biology, Department of Crystallography, Birbeck College, London, UK), who is well-known for his research on protein design. He said that the design of novel drugs, vaccines and proteins requires a detailed knowledge of the three-dimensional structures of the protein-ligand complexes and that this is best obtained by x-ray analysis. The proposed designs are explored using knowledge-based modeling with a relational data base of three-dimensional structures, interactive computer graphics, and techniques for simulation including molecular dynamics. Blundell presented data on the knowledge-based modeling of the serine proteinase domain of tissue-type plasminogen activator (tPA) and its interaction with its specific inhibitor, endothelial-cell plasminogen activator inhibitor.

Enzymes and Organelles

An informative lecture on the biotechnological potential of enzymes from extreme thermophiles was presented by R. Lamed (Department of Biotechnology, Tel Aviv University, Israel). The research discussed by Lamed in-

volved a joint project with E. A. Bayer (The Weizmann Institute of Science, Rehovot, Israel) and scientists from the Michigan Biotechnology Institute (MBI) in the US. Lamed said that a large number of proteins (many of which are enzymes) from thermophiles are more thermostable than homologous proteins from mesophiles. These thermostabile proteins have greater stability to extreme pH, solvent and salt concentrations. Recent developments in genetic engineering allow the production of an enzyme from one source in a different (industrially more convenient) host organism. Such manipulation allows the highly increased production of the desired enzyme. Extreme thermophilic anaerobes are particularly suitable as sources for unique depolymerizing enzymes, according to Lamed.

Lamed and coworkers have focused their research on the study of novel enzymes from the above sources and in gaining fundamental understanding of their mode of action. In one example, Lamed said that a secondary alcohol, stable at 90°C and at high levels has been purified and characterized by him and his group. They have used this enzyme to catalyze 100-gram scale production of different types of chiral alcohols (for example, chloro, nitrilo, olefinic, or acetylenic) which serve as building blocks for organic synthesis of various complex organic molecules. Lamed said that in many respects, this system has proved advantageous over and complementary to commercially available enzymes.

MBI has developed and characterized biochemically, highly thermostable and thermoactive amylases from anaerobes that function at temperatures above 80°C. *Clostridium thermosulfurogenes* produces a novel extracellular beta-amylase and *C. thermohydrosulfuricum* produces cell-bound pullalanase and glucoamylase. Compared to the respective commercial enzymes, these three enzymes are very similar in environmental catalysis requirements, which suggests their potential, according to Lamed, for single-step starch conversion processes. In addition, a new *Thermoanaerobacter* species has been found to produce glucose isomerase and glucogenic amylase activity simultaneously when grown on xylan. These activities in whole cells are environmentally compatible and convert starch directly to fructose. According to Lamed, the hemicellulases from this new organism show promise for industrial utilization.

Lamed said that perhaps one of the most in-depth efforts in this area in recent years has been the investigation of the highly efficient cellulolytic system of *C. thermocellum*. He and his group have recently isolated a multifunctional multienzyme complex from this organism which they have termed "cellulosome." A considerable amount of evidence has accumulated which indicates that cellulosome-like complexes also mediate the cellulolytic properties in a variety of other bacterial strains. Lamed said that the possibility that other types of specialized multienzyme-containing "hydrolysomes" occur on the cell surfaces of other microorganisms may have important implications in the general understanding and possible future industrial application of microbial cellular transformations of natural biopolymers.

K. Mosbach (Department of Pure and Applied Biochemistry, Chemical Center University of Lund, Sweden), who has an international reputation for his biotechnology research, presented an excellent talk on the design of new bifunctional enzymes by gene fusions. He described the formation of artificial enzyme hybrids obtained by gene fusion including beta-galactosidase-galactokinase and beta-galactosidase-galactose dehydrogenase. Mosbach also discussed potential practical applications and kinetics of these sequentially operating systems. Mosbach also mentioned other fused proteins including an esterase-mimicking polypeptide attached to a carrier-protein, antigens carrying marker enzymes such as α-interferon-β-galactosidase and proinsulin-alkaline phosphatase as well as enzymes tagged with affinity tails such as polycysteine and polyphenylalanine. Mosbach discussed the usefulness of such systems in competitive ELISA-assays and in affinity chromatography.

Mosbach also spoke about a new approach in separation technology, that of molecular imprinting, which he and his group developed. He discussed the potential of this new approach compared to conventional bioaffinity chromatography.

Bioreactor Technology and Control

B. Mattiasson (Department of Biotechnology, Chemical Center, University of Lund, Sweden) is well-known for his research on separation technology. In his talk, he said that the low productivity and dilute product streams are two reasons why production of bulk chemicals by means of biotechnology has been unsuccessful in competition with traditional chemical process technology. Thus, new process technology had to be developed. By integrating a separation step with the bioconversion, the product concentration could be kept low and thus the influence of product inhibition could be markedly reduced. Mattiasson also said that quick removal of the product from the medium can also help to protect labile structures and to isolate compounds that would otherwise be processed further. Mattiasson emphasized that there are many different ways to carry out the integrated separation step; the choice is very much dependent on the properties of the product to be isolated. Mattiasson discussed extraction with organic solvents and aqueous two-phase systems as well as the use of solid absorbents. Mattiasson and his group have extensive experience in these methods and were instrumental in their development. He also discussed membrane properties of the product molecule such as size, vapor pressure, and hydrophibicity

using examples of ethanol production to compare the different techniques.

Another first-class researcher in biotechnology, K. Schügerl (Institute for Technical Chemistry, Unviersity of Hannover, West Germany), presented a review of the field of measurement and bioreactor control including the excellent research that he and his coworkers carried out. He said that in order to utilize fully the biological potential of cells, their environment must be controlled to maintain permanently the optimal conditions for cell growth and product formation. On-line measurements supply the necessary information for this control and therefore, he only considered on-line and quasi on-line measurements in his talk. Schügerl said that the fluid dynamics of the multiphase system, chemical composition of the broth, cell concentration, and response of the cells to variations in their environment are the most important phenomena which influence the process performance. Therefore, all of these parameters must be taken into account in process control.

Schügerl spoke only about new techniques, established for bioreactors with difficult fermentation broths. These are: (1) determination of the dynamic properties of the aerated broth; (2) on-line analysis of the broth composition; (3) on-line and quasi-on-line determination of the cell concentration in the broth; and (4) evaluation of the levels of intracellular components and the biological state of the cells. To evaluate the local properties of the multiphase flow in a bioreactor, the fluid elements are labeled by a pseudorandom heat pulse series. The cross-correlation of the test and response signals are used for the determination of the flow pattern and the dispersion in the liquid phase.

Schügerl said that the ultrasonic Doppler technique has been applied to determine the local gas content, the velocity and the direction of the bubbles, and the specific gas/liquid interfacial area. The gas content, size, velocity, and direction of the bubbles are also determined by electrical conductivity probes. In order to ascertain the global properties of the multiphase flow, both phases are labeled with suitable tracers. The circulation rates and global mixing of the phases are determined by the stimulus-response technique. Schügerl said that all of these techniques are applied in bioreactors during cell growth and product formation.

Air-segmented continuous flow analyzers (autoanalyzers), on-line flow injection analyzers and on-line high-performance liquid chromatography (HPLC) are used to determine the composition of the broth. Fully automatic reactor operations are achieved by means of computer-controlled flushing, calibration, and blank correction procedures, as well as data acquisition, evaluation, and control. These techniques are applied for the control of several biotechnological processes, according to Schügerl.

Schügerl said that cell concentrations are determined on-line by the scattering of white and laser lights. The concentration of viable cells is also measured by monitoring the culture fluorescence that is due to the NADH of living cells in balanced growth. Other techniques, such as quasi-on-line acoustic resonance densitometry and on-line measurements of broth permittivity, are used to determine cell concentration. The reaction of the cells to a sudden change in their environment is detected by measuring the variation of the NADH content in the cells with a fluorometer. Quasi-on-line flow cytometry is used to determine cell sizes as well as their DNA, RNA, protein, and lipid contents. The levels of intracellular components (enzymes) are determined by permeating colorless compounds into the cells, where they are enzymatically converted to colored products. These products are then determined photometrically, either within the cells or after their permeation into the medium.

Schügerl said that with this information, the optimal physical and chemical environment of the cells can be maintained if suitable control techniques are utilized. Since the properties of the broths gradually change due to the variations of the substrate, product, and cell concentrations, and may change suddenly if an antifoam agent or a substrate (for example, soybean oil) is added to the broth, optimal closed-loop control with constsnt control parameters is normally not possible.

According to Schügerl, the combination of the aforementioned on-line measurements with adaptive control and a suitable strategy yield the optimal operation of a bioreactor.

I. Karube (Research Center for Advanced Science and Technology, University of Tokyo, Japan), who has an international reputation in biotechnology research, spoke in his presentation about new microbiosensors for estimation of fermentation parameters. He and his group have been developing several types of microbiosensors, using ion-sensitive field effect transistors (ISFET), micro hydrogen peroxide electrodes and micro oxygen electrodes, which were produced by semiconductor fabrication technology.

Karube said that an ISFET was utilized as a pH-sensitive transducer. Therefore, a potentiometric microbiosensor was constructed by combining enzymes which catalyze the reaction involving pH change and ISFET. A microbiosensor for the determination of urea was developed by using urease and an ISFET. Urease was successfully immobilized onto a gate insulator of ISFET by using polyvinylbutyral resin. An alcohol sensor was also developed by using acetic acid bacteria and an ISFET. The cell membrane of *Acetobacter aceti* has both alcohol dehydrogenase and aldehyde dehydrogenase. The injection of alcohol to the system caused the pH change due to the formation of acetic acid which could be measured

by ISFET. Karube said that this sensor can be utilized as an alcohol sensor with good selectivity.

Karube and his group also developed microelectrodes such as a hydrogen peroxide electrode and an oxygen electrode for the amperometric determination of glucose and glutamic acid. A hydrogen peroxide electrode was fabricated on silicon by using vapor evaporation technique of Au. A glucose sensor consisted of a hydrogen peroxide electrode and an immobilized glucose oxidase membrane. The micro oxygen sensor consisted of a micro-Au electrode, a gas-permeable membrane and an alkaline electrolyte absorbed gel. A micro glutamic acid sensor was prepared with a micro oxygen sensor and a glutamic acid oxidase immobilized membrane.

Downstream Processing

Downstream processing in biotechnology comprises a variety of processes used for the recovery and purification of products from microbial, mammalian, and plant cell cultures. The processes are employed for solid/liquid and liquid/liquid separations and in certain instances include cell disintegration followed by fractionation and purification of the intracellular products. There were many interesting presentations in this very important area of biotechnology. Unfortunately, due to space limitation, I will summarize only a few selected papers in this section.

Novel approaches for more efficient protein recovery using selective flocculation and precipitation processes was presented by M. Hoare (Department of Chemical and Biochemical Engineering, University College, London, UK). In his presentation, Hoare, a well-known researcher in biotechnology, said that the recovery and purification of proteins and enzymes from fermentation broths utilizes a sequence of operations each generally suited to their capability of handling process streams of varying urity. He stressed that an important early stage in the process for the recovery of intracellular products is the selective removal of cell debris followed by fractional precipitation of the proteins. Where a sequence of purification steps are used it is necessary to maintain a high yield at each purification stage in order to achieve high overall process yield. Hoare said that to aid the industrial-scale purification of proteins and enzymes with high product yields, three novel biochemical engineering approaches have been developed to facilitate in an integrated fashion the design and operation of early stages in the purification process.

He said that a novel and highly selective flocculation process for the recovery of cell debris particles from the soluble cell proteins has been developed. The resultant cell debris flocs are readily removed in low-speed continuous centrifuges and prevent interference of cell debris with the following recipitation stage. An engineering framework has been developed to describe the relationship between yield and purification factor, this being used as the basis for the on-line measurement and optimization of the performance of the fractional precipitation process. This framework provides the means whereby changes in purification profiles, due, for example, to different mixing conditions, can be taken into account.

Low-residence-time sonic conditioning was used to manipulate the properties of protein precipitate particles-for example, size, density, and resistance to shear breakup-in order to enhance their recovery in high-speed continuous centrifuges.

Hoare discussed the use of these three novel operations in sequence to optimize the selective recovery of enzymes and proteins from complex feed streams such as cell homogenates.

An interesting report on recombinant DNA technology for purification of proteins was presented by S. O. Enfors (The Royal Institute of Technology, Stockholm, Sweden). Enfors and his colleagues are well known for their excellent research in biotechnology. In his talk, Enfors said that genetic engineering has a great impact on the downstream processing of proteins. It may be used to modify proteins in such a way that their purification is facilitated. Furthermore, downstream processing can be improved by modifying the product to make it less susceptible to proteolytic degradation during the separation operations.

Enfors discussed one system which is based on the fusion of the product to Staphylococcal protein A (SpA) with a linking sequence that is susceptible to chemical or enzymatic cleavage. The affinity of SpA to IgG can then be used for purification of the fusion protein by affinity chromatography.

Enfors said that this system was further improved by the synthesis of a new IgG-binding molecule based on one of the five IgG-binding regions of SpA, but modified to be resistant to hydroxyl amine cleavage. This ligand (ZZ) was fused to human insulin-like growth factors (I and II) and to other peptides. It is now used for extracellular production of these compounds with *E. coli*.

A second system is based on the partitioning properties of *E. coli* beta-galactosidase in an aqueous two-phase system. After fusion of the model product SpA to beta-galactosidase, the partitioning coefficient of SpA was changed from 0.2 to about 3 for SpA-bgal. Careful adjustment of the composite of a mixture of polyethylene glycol, potassium phosphate, and cell disintegrate made it possible to extract this intracellular fusion product in a continuous process with a residence time of 5 to 10 minutes from the fermenter outlet.

M. R. Kula (Institute of Enzymology, University of Düsseldorf, West Germany) presented an informative report on extraction processes. Kula has an international reputation in many aspects of biotechnology research. In her discussion, she dealt primarily with liquid/liquid ex-

traction. She said that such extraction is a thermodynamically controlled unit operation well known in the chemical industry, utilizing water immiscible organic solvents to separate products by partition. Applications in biotechnology include the extraction of antibiotics, for example, penicillin.

Proteins are polar macromolecules and therefore insoluble in organic solvents. Extraction can be accomplished, however, using aqueous two-phase systems. Such systems are composed of two hydrophilic polymers or one polymer and a salt, which at certain concentrations in water are incompatible and form two immiscible aqueous phases. Kula said that such phases constitute suitable environments to extract and enrich proteins from cell homogenates by partition, removing cell debris as well as high-molecular-weight nucleic acids and part of the unwanted proteins under appropriate conditions. In this way a very difficult mechanical separation step in the clarification of crude extracts can be avoided, while achieving a substantial purification. The process is fast and can be performed easily in large scale with yields greaten than 90 percent for a single stage. Kula said that biospecific complex formation can be used to enhance the selectivity of extraction. Chromatographic separation steps can then be used for final purification.

An interesting report on integrated separation processes was given by G. Schmidt-Kastner (Division of Process Development, Bayer, A.G., Wuppertal, West Germany). He said that a fermentation broth or the supernatant of a cell culture is a complex mixture of substances from which the desired product has to be isolated in a multistep procedure. The sensitive nature of a product and the presence of damaging substances (for example, proteases) result in a loss of the desired product. A reduction in the number of steps in a downstream process and a rapid isolation are therefore of general importance, he said in some bioreactions, the product may be inhibitory or toxic to the microorganisms or, in a biotransformation, the equilibrium may not be favorable for a total conversion of the substrate into the desired product. In these cases according to Schmidt-Kaiser, an Integrated Operation-a process where two or more unit operations are running time coordinated or a process where unit operations are running in the same equipment-can overcome such critical situations.

Schmidt-Kaiser gave some examples of Integrated Processes:

- The isolation of a product during fermentation by cross-flow filtration
- The adsorption of a desired product directly from the fermentation broth by an ion exchanger (used for streptomycin, cyclohexamide)
- The extraction and cell separation in the same equipment using an extraction centrifuge (used for penicillin)
- The continuous evaporation of ethanol from the fermentation broth
- The removal of a product in a two-phase system where a bioreaction takes place in one phase and the product is partitioned in the other phase
- The use of a filter-dryer in which a sequence of operations such as crystallization, filtration, washing, and drying can be carried out without opening the equipment.

Sometimes the desired product requires a high level of containment for safety reasons and to avoid contamination. Schmidt-Kaiser said that this can be overcome by running the process and the subsequent purification steps in an Integrated Closed System by using sterile equipment, sterile filters, and sterile pipes.

Biological Reagents

An informative lecture on antibody engineering was given by M.S. Neuberger (M.R.C. Laboratory of Molecular Biology, Cambridge University, UK). The studies discussed by Neuberger involved a collaborative project with scientists from the Department of Pathology, Cambridge University, and the A.F.R.C. Institute of Animal Physiology and Genetics Research, Cambridge.

Neuberger said that the advent of the monoclonal antibody technology has allowed scientists to immortalize and clone lymphocytes producing the relevant antibody of interest. However, the *in vitro* manipulation of the DNA that encodes antibodies and its subsequent expression by introducing the modified DNA molecule back into cells now allows scientists to design (rather than simply immortalize) their own antibodies. This methodology, termed antibody engineering, permits a wide range of antibodies and antibody-related molecules to be synthesized and has also allowed detailed studies of the molecular basis of antibody interactions with antigens and effector molecules to be investigated. These studies and the production of chimeric and recombinant antibodies were discussed by Neuberger. He also spoke about the potential application of expressing antibodies in heterologous cell types or transgenic animals.

Examples of the uses to which which antibody engineering could be put, as discussed by Neuberger, include:

- Antibody-enzyme gene fusions to make conjugates for use in ELISA and other immunoassays
- Antibody-toxin gene fusions for the synthesis of immunotoxins in tumor therapy human chimeric antibodies for use in serum therapy as these are likely to be less immunogenic in patients than rodent monoclonal antibodies
- Antibody fragments (Fab, Fv, Fd or F (ab'2) for imaging or therapy

- Making specific alterations to the antibody sequence so as to alter effector functions to allow easy and specific conjugation with radionuclides or reactive chemicals
- Antibody-enzyme conjugates so as to achieve secretion of a specific enzyme in an easily purifiable form by virtue of the antibody's antigen specificity
- Site-directed mutagenesis studies of antibody interactions with effector molecules and with antigens.

So far, according to Neuberger, most work has been carried out using myeloma expression systems. Myelomas are specialized in antibody synthesis and secretion and therefore provide an ideal system for expressing transfected immunoglobulin genes.

Neuberger said that the expression of transfected IgG genes in lymphoid cell lines can also be driven by non-immunoglobulin transcription signals. For example, promoters from a heat-shock gene or from SV40 or human cytomegalovirus have been used successfully by Neuberger and colleagues as well as by other groups. According to Neuberger, the use of viral and heat-shock promoters has allowed the synthesis of antibody by transfectants of nonlymphoid cell lines to be evaluated. Neuberger and coworkers have achieved success with both IgM and IgG antibodies in nonlymphoid mammalian cell lines. Neuberger thinks that if the pattern of glycosylation is not severly affected, it is possible that non-lymphoid hosts may gain ascendency for the expression of engineered antibodies.

The introduction of immunoglobulin gene DNA into the mouse germline has illustrated the potential of transgenic animals for the production of monoclonal antibodies. Nueberger and colleagues have recently introduced the gene for a chimeric human IgA2 antibody into the mouse germline.

Neuberger said that the availability of an antibody gene expression system allows chimeric antibodies to be constructed, thus enabling controlled comparisons of the effector functions of the various human immunoglobulin classes and subclasses. The application of the techniques of site-directed *in vitro* mutagenesis to antibody genes yields valuable information on the interactions of antibodies with their antigens as well as allowing a detailed mapping of the contacts between the immunoglobulin Fc portion and antibody effector molecules such as Fc receptors and complement Clq. On the synthetic as opposed to the analytic level, the construction of chimeric and recombinat antibodies should provide a variety of novel molecules which may find use in diagnostic procedures or in therapy. In principle, it is possible to obtain a hybridoma that produces a monoclonal antibody specific for effectively any chemical determinate and to isolate the expressed V genes from such a cell-line. According to Neuberger, an intriguing possibility is that that V- gene-encoded antigen binding sites of Mabs may provide the biochemist with the basic building blocks that he needs for the construction of entirely new enzymes or proteins.

C. Hélène (Laboratory of Biophysics, INSERM U. 201, CNRS UA 481, Paris, France) and N.T. Thuong (Center of Molecular Biophysics, Orleans, France) presented an interesting report on the artificial control of gene expression by modified oligonucleotides. Hélène (who gave the talk) said that oligonucleotides complementary to messenger RNA (mRNA) sequences can be used to inhibit protein synthesis. Hélène and Thuong have covalently attached aromatic substituents to one or both ends of the oligonucleotide in order to increase the stability of the complexes. The linker was chosen in such a way as to allow intercalcation of the aromatic ring between the base pairs of the duplex structure formed by the oligonucleotide with its complementary sequence. According to Hélène, this intercalcation provides an additional binding energy that stabilizes the complex.

Hélène said that the oligonucleotide-intercalcator conjugates can efficiently block protein synthesis in cell-free extracts, in microinjected *Xenopus laevis* oocytes or in cells in culture. Also, the cytopathic effect of type A influenza virus is selectively inhibited by an oligonucleotide-intercalcator conjugate directed against the 3'-terminal sequence that is shared by the eight genomic viral RNAs. Trypanosomes in culture are selectively killed by an oligonucleotide-intercalcator conjugate targeted to the common sequence that is present at the 5'-end of all mRNAs in this parasite.

According to Hélène, in addition to increasing the stability of the oligonucleotide-mRNA complex, the intercalcating agent enhances the penetration across cell membranes and protects the oligonucleotide against exonucleases. Oligonucleotides can be covalently linked to substituents that can be activated either chemically or photochemically to induce irreversible reactions in the target sequence. A nucleic acid can be cleaved at a specific sequence or the oligonucleotide can be selectively photocrosslinked to the target sequence. These "activated" oligonucleotides behave as site-specific artificial endonucleases and could be used as tools in molecular and cellular biology, according to Hélène. Gene expression can be selectively controlled by inducing irreversible reactions in a specific mRNA or in genomic DNA. In addition, gene mapping on long DNA fragments or chromosomes could benefit from the use of these artifical endonucleases which can cleave duplex DNA at well-defined sites. Hélène thinks that these artifical endonucleases might complement or replace restriction endonucleases whose recognition sites are rather limited in size.

Hélène suggested that these studies provide a rational basis for the design of specific drugs that could inhibit virus or parasite development or block the expression of undesirable genes such as oncogenes.

Conclusion

There was an enormous amount of material presented at the very large 8th International Biotechnology Symposium. Therefore, it was only possible to present summaries of a limited selection of talks in this report. Most of the material in this report was presented by some of the top scientists in biotechnology research in Europe and the UK and was selected on the basis of informative and, in many instances, innovative research. The areas covered include a variety of topics in biotechnology and show clearly that scientists in biotechnology research in Europe are producing first-class work.

3/30/89

COMPUTER SCIENCES

HELIOS: A Distributed Operating System for Transputer-Based Computer Systems

by J.F. Blackburn Dr. Blackburn is the London representative of the Commerce Department for Industrial Assessment in Computer Science and Telecommunications.

Helios, developed by the UK's Distributed Software Limited, is a multitasking operating system designed to be used with the architecture of the transputer while remaining familiar to users of UNIX. The transputer (discussed in *ESNIB* 88-01:29-31 [1988]) provides in hardware many of the items often implemented in systems software, such as process creation, process switching, timeslicing, and interprocess message passing. Helios uses these primitives as the basic building blocks for an operating system that is designed to run on multiple processors.

Helios is a true distributed operating system in that there are no central services upon which the whole system relies. This results in increased system reliability since the failure of any processor, or the partitioning of the network, will not cause unrelated parts of the system to fail – they may, however, continue at a somewhat reduced capacity. The distributed nature of Helios is transparent both to the user at his terminal and to programs running within the system. Users do not need to be aware of the exact location of any services. This feature differentiates Helios from the network operating system where the distributed nature is more explicit.

The design of Helios is based on the client server model, where application tasks request services from system-provided server tasks. These server tasks may be present in any or all of the processors available, although each processor must run a standard minimum set. Other servers include file handlers, window managers, data servers, and spoolers.

Helios supports multiple processors and multiple users and is a fault-tolerant system. It provides graphics support under X windows VII and at present supports the language C and an assembler.

The target hardware for Helios includes systems for process control (Hema and Parsytec in Germany); high-performance workstations (Atari); and supercomputers (Parsytec, Meiko). The system uses transputer processes, performing tasks with no memory sharing. There is no timeslicing overhead and no extra process-switch overhead. Communication is by message passing using channels. Interprocessor/communication is transparent to the user and insensitive to network topology.

The client server model is a transparent set of distributed servers over a set of processors. The protocols are common in that every server accepts the same standard. This enables use of a standard set of tools. The system uses a device-independent interface and is extendable at the option of the user.

Overall Structure

On every Helios node there is a Helios nucleus containing a kernel library for message handling, etc.; a system library; a server library; a loader; a process manager; and link guardians. On some Helios nodes there are Helios utilities including a C library, a shell, window-manager, first-in-first-out pipe buffer, a Ram disc, and file server.

For the input-output server the PC discs are in local (MS-DOS) format. All discs, including floppies and networked discs, are available. The system has access to a PC screen and keyboard. PC graphics are to be available soon, using a GKS subset for SUN graphics through X-

windows. Control is available through serial, parallel, mouse, or clock mode. Processes can be allocated to processors as desired. Users' jobs are not shared on a single processor; rather, a processor is assigned to a user.

Languages and Tools

The shell used by Helios is a complete clone of the UNIX C-shell with pipes and reduction, complex control structures, variables, aliases, and background jobs. It features cursor-controlled line editing, automatic command completion, automatic file name completion, and multiprocessor support. Its commands are UNIX-like commands, and the program development tools are similarto UNIX tools. An identical make-file syntax is used.

The programing languages of Helios are both sequential and parallel. These include Helios C, a Meiko FORTRAN, INMOS OCCAM, Modula II, and Pascal. Some traditional and newer languages being implemented include Lisp, Parallel Prolog, Parallel C, Basic, BCPL, and STRAND.

The support on host systems includes: SUN OS on SUN systems; UNIX 4.2 on Orion or VAX systems; VMS on VAX; GEMDOS on Atari ST, and other processors by arrangement.

Windowing support consists of dumb windows, simple windows and X-windows. The so-called dumb windows essentially provide lines of C code to the screen. This supports text-only screens and is very small and simple. Simple windows, on the other hand, support full graphic screens and use mouse switching between windows. singel window provide simple tilting only and limited access to graphics. X-windows have wide-ranging industry support, excellent graphics, and font support and are neither small nor simple.

The I/O server provides access to host resources. These include PC for B004; Atari ST for Atari Abaq; Atari ST for Kuma K-MAX; PC for Meiko; SUN for Meiko; VAX for Caplin boards; Megaframe for Parsytec; Amiga for Commodor; and others.

Programming under Helios

Programing under Helios makes use of message passing, lists and queues, semaphores, a system library, a Posix library and a C run-time library. Floating point support is provided for terminal I/O, I/O events, and debugging.

In message passing all messages are directed to ports. A message control block consisting of 16 bytes contains flags, C size, D size, Destination port, reply port, and function/result.

The system library implements the general server protocol with task management, resource tracking, and environment enquiry. A task is an entity managed by Helios. The data structures in the system library are objects and streams, where a stream is an active, as opposed to passive, object. Examples of passive objects are a current directory or loaded task force. Examples of active objects are "open file (or directory)" and "executing task force." A passive object reference contains name and capability but has no resources allocated in the server. An active-object reference contains name, capability, and access part and may have resources allocated in the server.

Some examples of object operations are:

- General server protocol functions
  - Locate (context, name)
  - Create (context, name, type, info, infosize)
  - Object Info (context, name, type, info)
  - Server Info (context, info)
  - Link (context, name, object)
  - Set Date (context, name, dateset)
  - Protect (context, name, matrix)
  - Delete (context, name)
  - Rename (context, name, to name)
  - Refine (context, mask)
  - Open (context, name, mode)
- System library function
  - Copy object (object)
  - New Object (path name, capability)
  - Result 2 (object)
  - Close (object)
  - Abort (object)

Some examples of stream operations are:

- General server protocol functions
  - Read (stream, buffer, size, timeout)
  - Write (stream, buffer, size, timeout)
  - Seek (stream, whence, pos)
  - Get File Size (stream)
  - Set File Size (stream, size)
  - Get Info (stream, info)
  - Set Info (stream, info, infosize)
  - Reopen (context, name, mode)
  - Close (stream)
- System library functions
  - New Stream (pathname, capability, mode)
  - Result 2 (object)
  - Abort (object)

The Posix library implements as much of the Posix/UNIX function set as possible under Helios. However, all user and group identification functions are omitted because Helios has no concept of users; fork ( ) is replaced by Vfork ( ); and there is no job control in the Posix library. This latter is a possible future extension. A few extensions include Sopen (stream), fdstream (fd), and cd obj ( ), which converts Helios stream into UNIX file servers. Thus, the Posix library provides a familiar I/O environment and provides for signal handling.

The C run-time library is built on top of the Posix library. It contains some rearrangements including: string routines moved to the utility library, signal routines moved to the Posix library, math routines moved to the floating point library, and the floating point I/O moved to the floating point C library (FpClib). Two extensions are file no (file) and fd open (fd). The C runtime library provides ANSI standard C run-time, buffered IO, and formatted I/O.

The floating point libraries are the FpLib and the FpClib. FpLib provides: C library math routines, INMOS emulation routines, dummy emulation routines, and routines for processor type. FpClib provides floating point entries to print f and scan f. The single version always uses emulation in order to be portable.

The terminal I/O provides interactive streams using windows, consoles, serial ports, and parallel ports. It also provides control functions in which all terminals are controlled via ANSI sequences. Mapping to actual controls is done in the driver of the device.

I/O events serve to deliver asynchronous events to a client. Event producers are the mouse driver, the keyboard driver, windows, and consoles.

For debugging, the existing facilities in Helios include a server debugger, a trace vector, an I/O debug function and embedded symbols. Planned future facilities include a C source debugger and a debugging interpreter.

Summary

The Helios operating system has the virtue of working efficiently with the architecture of the transputer and at the same time having many characteristics of the widely used UNIX operating system. As more transputer-based parallel processors like those from Meiko and Parsytec come into use the efficiency of Helios in its use of primitive operations like process creation and interprocess message passing will prove most useful. Its similarity to UNIX will make it more acceptable to users familiar with the UNIX system, which is now so widely used in Europe and in the US.

Reference

Helios Developers Notes, Distributed Software Limited, 24 Brewmaster Building, Charlton Trading Estate, Shepton Mallet, Somerset BA4 5IE, United Kingdom.

2/12/89

ENGINEERING

Research at Chalmers University of Technology, Sweden

by Daniel J. Collins. Dr. Collins was the Liaison Scientist for Aeronautics in Europe and the Middle East for the Office of Naval Research European Office. He has returned to the Naval Postgraduate School where he is a Professor Aeronautical Engineering.

Chalmers University of Technology, in Göteborg, Sweden, founded in 1829, now has an academic staff of 200 professors and associate professors. Each year the university grants about 700 master's degrees and 80 doctorate and licentiate degrees. This means that on the average around 40 percent of Sweden's graduate engineers come from Chalmers University of Technology. The heavy emphasis on research at the university is reflected in the fact that 60 percent of the university's budget is directed at over a 1000 research projects.

My visit was primarily concerned with research in fluid mechanics and controls. I visited two departments in the School of Mechnical Engineering and one in the School of Electrical Engineering. Although the university uses the term "departments" for subdivisions of the different schools, I believe that these subdivision are closer to the institute structure of Germany in that the work is centered around one or two professors. There are, for example, 20 professors in the Mechanical Engineering School and 19 departments. I shall begin my research review with the Department of Control Engineering in the School of Electrical Engineering.

School of Electrical Engineering

The Department of Control Engineering in the School of Electrical Engineering is directed by Professor B. Qvarnstrom, assisted by Professor C. Breitholtz. There are 15 people in the department with about five doctoral students. The department's work is basically applied research directed at the application of new control methods to marine and automobile propulsion systems,

chemical processes, paper machines, and man-machine problems in robotics. For example, a recent application of control theory by the department was the development of an automatic dispatcher for taxi cabs in a medium-size city.

Breitholtz has analyzed real-time models of tunnel furnaces (Palmgren et al., 1988) – analysis of rotary kilns and tunnel furnances is a favorite topic of most process control groups in Europe. Incorporation of a real-time model into the process controller has several advantages – among them, on-line state and parameter estimation and prediction. The present analysis develops finite dimensional nonlinear models from the infinite dimensional primary process using polynomial approximations of the space-dependent variables. An observer structure based on the Kalman filter is used as a nonlinear predictor. Two possible cost functions are used – one reduces the influence of measurement errors, and the other reduces the influence of modeling errors. Future work will be directed at further study of modeling error reduction.

One of the main emphases of the group is on the development of improved controllers for reduced order systems. Model reduction over a large range of variables and with distributed parameters is based on the method of weighted residuals (MWR). The approach can be applied both to ordinary and partial differential equations and leads to polynomial approximations as described in the last project. Breitholtz has recently reported on disturbance rejection in packed bed binary distillation columns using a MWR subdomain analysis (Molander and Breitholtz, 1987). A linear quadratic model in combination with a Kalman filter was based on a low-order model of the binary distillation column obtained by the subdomain method. Even when the infinite dimensional process was modeled by a finite dimensional model of order 6, the linear quadratic controller was better that the standard PI controllers. Previous work in this area is referenced in the paper on binary distillation columns. Present work using the MWR is based on orthogonal collocation for distributed parameter systems with the use of partial pole-placement.

School of Mechanical Engineering

The Applied Thermodynamics and Fluid Mechanics Department, directed by Professor E. Olsson, has a total staff of about 30 and about 17 doctoral students. The research program is oriented towards fluid mechanics and heat transfer with special emphasis on boundary layer flows and turbulent flows. Research in numerical solutions of fluid flow problems is primarily applications-oriented and has not involved the development of computer codes. In addition to the research in vehicle aerodynamics and turbulence measurements that I am going to highlight below the department does research in turbomachinary, ventilation, combustion, and heat exchangers. A recent doctoral thesis in the turbomachinary area was, for example on hot-wire measurements in the impeller passage of a centrifugal fan.

The aerodynamic wind tunnel (1.5 x 1.1 m, maximum velocity of 65 m/s) is used for vehicle aerodynamics with emphasis on cars. Support for this activity comes from the Swedish car makers, Volvo and Saab. Recent work is reasonably sophisticated in that a five-beam two-color laser Doppler anemometer (LDA) has been used to obtain simultaneously the 3-D flow field behind a vehicle-like bluff body (Rutberg, 1987). Mean velocities as well as turbulent intensities were obtained at 266 positions. The numerical calculations of the flow using the Phoenics code with 14,520 cells took 29.5 hours on a VAX 11/750. A κ-ε model for turbulence resulted in considerable differences between the experimentally determined flow and the predicted numerical model. Other work in vehicle aerodynamics is done in a departmental water tunnel.

In a more fundamental study (Johansson and Karlsson, 1988), T. Johansson, who is in charge of the vehicle aerodynamics group, has used simultaneous 2-D LDA measurements to obtain higher order mixed moments of the velocity fluctuations in a flat plate boundary layer down to a dimensionless wall distance of $y^+ = 1.5$. With a focal diameter of 70 microns for the laser optics measurement resolution normal to the wall was equal to half of the viscous scale length of 150 microns. What is exciting about this work are the comparisons of the experimental measurements with recent direct numerical simulations done by Kim et al. and Spalart of NASA. The turbulent intensities determined at a Reynolds number of 1750 agree more closely with the lower Reynolds number work of Kim et al. despite the fact the Spalart numerical work was closer to the experimental Reynolds number. The authors speculate that the spatial or temporal resolution in the computations of Spalart may have been too low. In contrast to this result, the comparisons of the energy budget calculations of Spalart in the boundary layer less than y^+ of 40 are in striking agreement with the experimental results. This agreement gives experimental support for the direct numerical simulations.

Professor U. Hall, who has an industrial background in jet engines, has recently joined the Turbomachinery Department. Hall's research program, which is just getting started, has three primary axes. The first research topic deals with transient flows in large-scale pipe as would be found in large-scale heating systems in, for example, the city of Göteborg. Part of this work on a smaller scale is directed at ink jet analysis. One of the department's doctoral students is beginning work on flutter analysis, in cooperation with the Flygmotor company which is located in Göteborg. In addition to numerical analysis, cascade tests will be used to verify calculation

methods. Finally, in the future, work will begin on lose correlations in compressors and turbines with particular emphasis on the effect of optimization methods.

Conclusions

Chalmers University of Technology is an important Swedish research center in the engineering fields. Although there is great emphasis on applied research, there are also significant contributions at the fundamental level. I think the boundary layer measurements and the comparisons with direct numerical simulation are a significant contribution to the fluid mechanics literature. The method of weighted residuals is a well-known method, but the Göteborg control group is the first of the many control groups I have visited in Europe that is making a systematic application of the technique in the controls area.

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2/6/89

FLUID MECHANICS

Fluid Mechanics and Controls at Norway's NIT

by Daniel J. Collins. Dr. Collins was the Liaison Scientist for Aeronautics in Europe and the Middle East for the Office of Naval Research European Office. He has returned to the Naval Postgraduate School where he is a Professor of Aeronautical Engineering.

The Norwegian Institute of Technology (NIT) was established in 1910 in Trondheim, Norway. Although some newer and smaller Norwegian technical schools have been established recently, NIT, with its 6000 students, is still the main technical research center in Norway. Since Norway has a population of about 4 million, it is relatively easy to characterize the national research effort in any given discipline which for my visit was fluid mechanics and controls. The primary emphasis of my visit was on the Hydro and Gas Dynamics Division of the Mechanical Engineering Department, but I also talked to professors from the Engineering Cybernetics Department and the Telecommunications Division of the Electrical Engineering Department.

I will begin with a discussion of the fluid dynamics research of the Hydro and Gas Dynamics Division and conclude with a discussion of the controls and navigation research of the other two divisions. Some of the technical results reported below involve the SINTEF Group, which was originally set up by the university to aid the development of NIT research. Although this is still somewhat true, the SINTEF Group is now the largest contract research establishment in Norway, and with some 2000 employees has become somewhat independent of the university. Nevertheless, there appears to be a healthy research environment at Trondheim in part due to the existence of SINTEF. One important contribution that the company makes is to support a large percentage of the doctoral students.

Fluid Mechanics

The Hydro and Gas Dynamics Division has a technical staff of 14, a student body of 120, and 10 students working for the doctoral degree. It is worthwhile mentioning that there are two different doctoral degrees in Norway, one of which represents somewhat less work than the American doctorate and the other somewhat more. Research interests match the organized groups in the division which include:

- Hydraulic machinery (one professor, one lecturer)
- Oil and pneumatic hydraulics (one professor, one lecturer)
- Thermodynamics of turbomachinery (chair not occupied)

- Aeronautical and gas dynamics (two professors, two lecturers).

As is often the case in a smaller country, there is a large emphasis on applied research which can lead to a technology edge or nitche that the country can exploit.

Dr. L. Saetran told me that much of the research in fluid mechanics at NIT is connected with the oil industry, with ship designs, and with surface effects such as gravity spreading of heavy gases. One of the recent projects in the division's atmospheric wind tunnel (2.7x2 m) was a study of hot plumes formed on an oil derrick. In another project, one student(Jens Holen) has developed a fascinating animation showing the development of a pool fire in a ventilated room of a derrick. The calculations, from which the animation was made, were based on a simultation done on a Cray XMB where 25 seconds of the fire took 1 hour of calculations. The animation, displayed on a PC, is a Lagrangian representation of the fire, showing path lines with temperature variations shown in color.

Saetran's experimental interests are reflected in a series of papers he has had on the measurement of wall shear stress. Since the wall shear stress is a critical parameter in the transportation of heat and mass in ducts, Saetran has investigated the use of static pressure holes to determine the shear stress. He has also compared five indirect methods of inferring the shear stress based on the velocity profile (Saetran, 1987). In other recent work, Saetran has been investigating reactive scalar mixing layers where two species react with each other under isothermal conditions. These studies show that the turbulent cross-correlation between the reactant concentrations is of major importance in determining the mean reaction rate.

An example of the work done in computational fluid dynamics (CFD) by the Hydro and Gas Dynamics Division is a recent article on the validation of a 3-D Euler/Navier-Stokes finite volume solver for a radial compressor (Eriksson and Billdal, 1988). A time marching 3-D compressible code is used to describe flow in a turbomachine. A cell-centered finite-volume technique is used with explicit Runge-Kutta time stepping and with an algebraic turbulence model. For the well known Eckardt impeller the viscous model was significantly closer to the experimental data than the Euler model. A thin layer version of the viscous solver also gave very close agreement with the full Navier-Stokes solver.

Professor H. Brekke is interested in turbomachinery with particular reference to hydroelectric powerplants. His main investigations have been directed at large Pelton turbines. He is interested in the next generation of Pelton turbine, which could have 2000 meter heads and power outputs of 860 MW. This should be contrasted with existing machines of about 315 MW and 885 meter heads. In the larger machines, the efficiency could be increased by about one percent, but erosion problems may be significant. Another aspect of his research is the use of a structural matrix approach to the mathematical modeling of hydropower governing systems. Many of the powerplants in Norway are of the high-head type with complex tunneling carved out of rock. Brekke has used the structural matrix approach to study the stability of the powerplants with full-scale testing so far on eight power stations (Brekke and Xin-Xin, 1988).

Other recent activity in the division has included studies of transient pipe flow energy variation, development of a new hydraulic spool valve, and remotely operated hydraulic control systems (Dr. O. Bratland). Another problem investigated by Professor P. Krogstad is that of the hazardous release of heavy gases. Wind tunnel simulations have been made of the release of a heavy gas near a building and also of a simulation of the experimental program of heavy gas release at Thorney Island (Knudsen and Krogstad, 1987). The Thorney Island test was simulated with respect to the bulk Richardson number and at a scale of 1:50. Although the front concentration peaks were reproduced satisfactorily, an average of five runs gave a lower concentration than full scale. The duration of the dispersion process was also somewhat longer.

An interesting experimental study of ignition in internal combustion engines (T. Bjorge) using laser Doppler anenometry gives some idea of the doctoral work at NIT. This study, which may seem surprising since Norway does not make any cars, was in cooperation with Volvo. The effect of the spark on the flow field was studied both in long cylinders and in a combustion bomb. Part of this doctoral work was done at the Volvo research center in Göteborg, Sweden.

Controls and Navigation

The only cybernetics department in Norway is located at NIT. The department has five divisions, one of which is Automatic Control (four professors). Dr. T. Onshus who does research in process control (see below) indicated that the department is strong in the analysis of dynamic positioning of ships. This activity is carried on in conjunction with Albatross, a Norwegian company which has about 80 percent of the world market in ship positioning. As one might imagine, there is a strong connection with the safety of off-shore facilities. Both failure detection techniques and distributed microprocessor controllers are used in the control algorithms.

Professor C. Solheim has recently reported on the design and analysis of a class of optimal discrete control systems. He presents a design method for an optimal control problem which has specified stability in that the eigenvalues are given. In this case the weighting matrix on the states (Q) cannot be given arbitrarily, and Solheim gives

a flexible design procedure of a recursive nature which permits the determination of Q.

Professor Jens G. Balchen stated that two of the other divisions are centers of excellence in Norway for robotics and for process control. At present there are 20 doctoral students in robotics, 12 of them funded by the National Science Foundation for Norway. The research concerns adaptive control of manipulators, and Cartesian control of redundant manipulators as well as coordination of different robotic tasks. This type of work is similiar to that of other robotics centers that I have visited in Europe. What I consider an important feature of this type of work also exists with this robotics group – a tie in with a robot company. In the process control area, a recent doctoral thesis by Onshus was on the modeling and control of iron-oxide-reduction in a countercurrent moving reactor bed.

My final visit was to Professor B. Forssel of the Telecommunication Department. Forssel indicated that he was the only Norwegian professor specializing in navigation. He is particularly interested in the GPS system and the accurate position of ships at sea with this method. He has been involved with the design of receivers for the GPS system for ships.

Conclusion

It is interesting to note the strong effect that the oil industry and the off-shore facilities of Norway has on the research conducted both in fluid mechanics and in the controls area. NIT is quite strong in applied fluid mechanics particularly in the modeling and simulation of combustion and fires. It will also be interesting to see what develops in the robotics area. Almost every country I have visited in my stay in Europe has established robotics centers; hopefully, something productive will come out of all this activity. It would appear that technically competent people are in short supply in Norway since in the controls area there are four unfilled positions at NIT, and there is also a vacancy in the turbomachinery area. I was told that there is strong demand for the students graduated from NIT. Overall, although the research has a strong applied applications aspect I found the individuals to be very competent. In addition, many of the professors have strong contact in America either through sabbatical or work visits.

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2/3/89

Biofluiddynamics of Balistiform Locomotion or: What triggers the triggerfish? - A Cambridge colloquium by Sir James Lighthill -

By Marco S. Di Capua and David Feit. Dr. Di Capua is the Liaison Scientist for Physics in Europe and the Middle East for the Office of Naval Research European Office. He is an experimental physicist on leave until August 1990 from the Lawrence Livermore National laboratory (LLNL) of the University of California. Dr Feit, the Liaison Scientist for Acoustics, is on leave from the US Navy David Taylor Research Center until January 1990.

Sir James Lighthill, who retired on 31 March 1989 from the Provostship of University College London, was introduced at a recent weekly colloquium of the Department of Applied Mathematics and Theoretical Physics of Cambridge University as the "greatest fluid dynamicist and applied mathematician of the century." As a teacher he has spawned a great school of fluid dynamicists. His lecturing skills are legendary and this colloquium on triggerfish locomotion was an inspirational example of his style. We hope this article provides the ESNIB audience a taste of what we saw and heard, and a glimpse of future research as Sir James joins, as an Honorary Research Fellow, the Department of Mathematics of University College London.

Triggerfish "constitut(e) Balistes and related genera of the Balistidae family ...inhabiting chiefly warm seas, being often fantastically colored." (Webster, 1961). What the dictionary does not describe, and what Sir James elaborated upon, is the propulsion method that allows these rigid-bodied creatures to quickly dart about, in bullet like fashion, escaping from predators in a seeming effortless way.

Fish Locomotion and the Role of Tails and Fins

The forward motion of fish results from backwardly directed water momentum originating with high amplitude motion of the fish's motile surfaces including the body and fins. Texts (Lighthill, 1976, and Blake, 1983) describe anguilliform locomotion of eel-like fish and carangiform locomotion of pelagic fishes. Anguilliform locomotion results from a wave of lateral motion (as viewed from above the fish) along the fish body. This wave, in which posterior movements lag behind the anterior ones, has a backward velocity that exceeds that of the fish in the waterand has a ratio of body length to wavelength larger than one. In carangiform locomotion, the ratio of body length to wavelength of the body deformation is smaller than one. Therefore, the wave is more like a lateral oscillation, with high amplitude gradients, that propagates to the back of the fish. The wave reaches the tail and produces a rapid twist that sheds the backward momentum.

At this point in the lecture, Sir James introduced the function of tails and fins in reducing unwanted sideways motion that results from propulsive action. For carangiform fish, this yaw and sideslip cause a swimming drag that is 3 or 4 times the gliding drag.

In sharks and other fish heavier than water, asymmetric fins have a different role, becoming hydrodynamic lifting as well as control surfaces. Such fish must swim constantly to avoid sinking.

Evolution and Locomotion

According to Sir James, fish locomotion fits within the context of species adaptation to the environment. Evolution, in some cases, favors fast locomotion, with a minimum of energy expenditure, for effective food hunting and escape from predators and to cover the long distances between habitat and spawning grounds. In other cases, it favors armor that, while reducing mobility, increases the probability of survival. Reefs provide plenty of food, so survival of triggerfish in this habitat requires a further adaptation that prevents the triggerfish from becoming food itself.

Triggerfish Locomotion. Triggerfish, according to Sir James, are rather inflexible. Therefore, their locomotive adaptation consists of a wavelike and twistlike motion of median fins on the top and bottom ridge of the fish. This motion produces uncanny speeds.

Sir James explained the effectiveness of these fins through slender-body theory. Hinged fins that are smaller than the rigid body they are attached to, according to this theory, enhance the shed momentum. Symmetric motion of the superior and inferior fins also eliminates the extra drag that would otherwise result from lateral body recoil motions. These motions enhance the thrust (shed momentum) without enhancing drag (shed energy).

The fins of the triggerfish have a large number of spars spanned by a membrane. These spars, actuated by individual muscles, are hinged in the body so a sequential contraction of the muscles, propagates a sideways motion of the spars. The amplitude of this motion increases towards the back of the fish. This wave motion, resulting from the angular phase lag between the fore and aft spars of the fin, produces a backward component to the momentum. As in the case of anguilliform locomotion, the wave velocity must be larger then the swimming velocity of the fish.

Conclusions

Modeling of the triggerfish is more complicated than modeling anguilliform propulsion because of the three-dimensional nature of the fin motion resulting from pivoting fins attached to a rigid body. However, Sir James, in his elegant style, split the problem into two two-dimensional problems: the rigid fin hinged on a rigid body and wavelike motion of a flexible fin. Thus he was able to answer the question, to first order at least: what triggers the triggerfish?

Although Sir James, in response to a question from the audience, downplayed the potential application of these principles to marine technology, we were reminded of discussions by Ffowcs-Williams (1986?) on surface drag modification by tailoring of vessel surface compliance. These notions, coupled with advancing technologies of active control, offer intriguing possibilities for advances in drag reduction and propulsion efficiency enhancement.

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4/9/89

MATERIALS SCIENCE

Giant Magnetostrictive and Amorphous Alloys for Actuators and Sensors

by Bernard McTaggart. Mr. McTaggart is Head of the Transducers and Hull Arrays Division at the Naval Underwater Systems Center, New London, Connecticut.

The Second International Conference on Giant Magnetostrictive and Amorphous Alloys for Actuators and Sensors was held at the Don Carlos Hotel in Marbella, Spain, the week of 10-14 October 1988. The conference was sponsored by Sensglas Terfenol AB of Lund, Sweden and was held primarily to discuss the new "rare earth" magnetostrictive material terfenol and its merits and potential applications. Although the material was developed by the United States Naval Ordnance Laboratory (now the Naval Surface Warfare Center [NSWC]) with defense application in mind, the material has significant potential for industrial actuator and robotics applications. In fact, it would appear that the industrial market will orchestrate the future investigations in the material. There were approximately 50 participants, including 17 speakers from almost all of the European countries and Japan. There were several defense-oriented participants, yet the majority were from the industrial arena and most of the papers were weighted towards industrial application of the material.

Demonstrating the various applications of the material was a limited display of terfenol devices ranging from linear motors to acoustic transducers. Most of these were provided by Sensglas, yet there was a very unique Kiesewetter motor provided by L. Kiesewetter of the Technische Universität of Berlin and an "inch-worm" motor by SKF Company of Göteborg, Sweden. These are essentially linear actuators that through a process of clamping and unclamping can generate high speed and high force simultaneously. Other demonstration devices were an elliptic transducer, a linear position transducer, and a sound projector (all using terfenol), and a torque sensor using amorphous magnetoelastic material.

The most significant point that I drew from the meeting was that terfenol is still undergoing significant development, processing is still being improved, properties are still being characterized, and industry is not yet at the point that properties can be established for volume producibility and reproducibility. Production methods and stoichiometries are as yet customized to the application. This is not to say that a volume production goal is not being pursued but rather that as yet terfenol is still an emerging technology. The unlimited potential of the material in so many applications, as shown by the display, certainly merits its pursuit and total support. It appears at this stage in terfenol development that an infusion of interest by industry is what is needed since waiting for defense funding in the past has probably delayed development progress.

Terfenol is a remarkable material. Its strain potential (d1/1) is 3000 ppm versus 200 for the best piezoelectric ceramic (PZT). It maintains this high strain at temperatures as high as 400°C. The energy potential is 10-20 times that of PZT. The material is of particular interest to the underwater acoustics sonar transducer designer because of its low sound velocity as well as its high-energy density. A given sonar transducer could be made significantly smaller and provide substantially more power by replacing piezoelectric ceramic with terfenol. Engineers designing control devices could get far more displacement and force for a given design and at higher temperatures and quicker response times than currently used hydraulics. I was impressed with the giant leaps that have already taken place with the producibility of the material in that 15-cm-long by 2-cm-diameter rods can now be produced as opposed to the cigarette-size pieces that were the maximum size produced not too long ago.

Terfenol – the Presentations

The opening paper was presented by A. Clark of NSWC, White Oak, Maryland, who discussed the history of the material and its chemistry and properties. Terfenol is essentially iron with rare earth additives – i.e., additives from the lanthanide series like dysprosium and terbium. Terfenol was designed, developed, and first produced by Clark and H. Savage, also of NSWC. Terfenol received its name from terbium ("ter"), iron (Fe), and NOL. A particular variation of the material called terfenol-D includes "D" for dysprosium. Although fabrication of the initial samples was done at NSWC, the process was later transferred to the Ames Laboratory at the Univer-

sity of Iowa where research on the material had also been done and improvements in processing were being undertaken. Edge Technology was just recently formed in Ames, Iowa, as a private corporation to further advance the processing, production, and marketing of the material apart from a university environment. Sensglas Terfenol in Lund, Sweden, was even more recently formed to carry the material to the European market. It would seem that the Lund Institute of Technology (LIT) has had an avid interest in the material for some time now and most of the principals in Sensglas Terfenol are from the institute. I might add that a significant group of participants in the meeting were students and colleagues of F. Olsson at LIT. I was disappointed in the paper by Olsson in that it was oriented to the business aspects of introducing the material to industry vice the technical issues I am sure he is attuned to.

O.D. McMasters of Edge Technology presented a paper which discussed "growing" the material using manufacturing processes like modified Bridgman methods and "float zone" techniques. These are essentially seeding processes whereby dysprosium is introduced to the terbium-iron compound. Process improvements are continually being developed in the interest of maximizing material performance characteristics and optimizing the stoichiometry and preparation of the desired shapes. The material has a marked sensitivity to both chemistry composition and processing. Percentages of dysprosium and terbium significantly influence the physical properties of the material and their dependence on stress, temperature, and magnetic field. Growth of the material is essentially dendritic and results in the development of discrete boundaries and planes. Minimization of grain boundaries and twin planes "twinning" are processes still being optimized. In view of the sensitivity of the material to both chemistry and processing, the continued pursuit of new fabrication techniques is a culprit in variations of the material currently experienced from batch to batch. It is interesting, however, to note that advantage can be taken of all these sensitivities. There are requirements and interest in a material having a varying modulus with field as there is also an interest in twinning to take advantage of large magnetostriction "jumps" coincident with twinned material.

Standardization in the characterization of the properties of the material is an area of concern and was a significant topic of discussion. K. Pitman of the Admiralty Research Establishment, Poole, UK, emphasized the need for standardization in areas of measurement of coupling coefficient, piezomagnetic constants, permeability, etc. This need was apparent from other presentations as well wherein it was evident that variations in data could be attributed to measurement techniques. Great Britain has been a very enthusiastic investigator of the application of terfenol. J. Oswin of British Aerospace had built a flextensional transducer using terfenol and provided reading material on a comparison of its performance to piezoelectric ceramic. The particular design chosen is not a good one since the flextensional configuration is stress-limited rather than field-limited where terfenol would show its superiority.

Terfenol is a hard, brittle material like glass and is extremely difficult to machine to shape. Typically, Electrical Discharge Machinery and centerless grinding techniques are employed. Small shapes, as for example 6-mm-diameter rods, presently require grinding. J.D. Stahl of LIT discussed the problems of machining and the necessity for optimization of configuration to the required application to avoid stress buildup and ensuing fracture. Stahl presented work being done in the area of simulation programs to determine the dynamic behavior of terfenol rods and optimum configurations for contact surfaces. In the design of high-force positioners and control devices, the contact surface is very critical and without proper design and finish is sensitive to fracture.

Cost of terfenol was a major topic of discussion. Since it is now used at an experimental level, it is considered quite expensive. With volume usage, it is projected that the cost will drop significantly. At present, the cost is approximately $150 per inch for a 0.6-cm-diameter rod. By 1998, this price is expected to be at $50, given an optimistic production growth rate. J. Oswin of British Aerospace indicated that compared to piezoelectric ceramic, the cost of the drive material will probably always be appreciative. Given the appropriate application, however, the cost increase could be justifiable. That seems to be a critical issue. Terfenol is not a one-to-one replacement for piezoelectric ceramic but rather the designers need to find a specific niche where a high-energy or large-force-drive or low-frequency application is required.

F. Claeyssen of GERDSM, DCAN, a consortium of aircraft manufacturers, Toulon, France, presented one of the most interesting papers of the conference. His paper shows a definite interest in the part of the French Navy to develop high-power low-frequency sources for deep underwater application. Claeyssen discussed a terfenol "quadripode" tonpilz transducer design that found its niche and made good use of terfenol to achieve very high power at a relatively low frequency in a small package. Quadripode refers to four rods of terfenol as the active elements in a double-mass-loaded ("tonpilz") design. To optimize the full power capability of the terfenol, a coolant was supplied to address heat buildup in the magnetic circuit. Pressure compensation was also provided to address the characteristic stability problem of terfenol with depth. This was an excellent application for the material. The issue of the producibility of the material was apparent in this paper as different batches of the material obtained by GERDSM manifested a wide variation in performance. Claeyssen also discussed the importance

of the design of the magnetic field to eliminate stray fields and optimize efficiency. This is an obvious concern to all users because of the low permeability of the material and the resultant large number of windings to effect the appropriate electric field. Significant attention was given to this in many of the conference papers. P. Kuhn of Martin Marietta, Baltimore, discussed modeling the magnetic driving and biasing circuits to obtain optimum design performance using an off-the-shelf analysis program (MSC/MAGGIE by MSC Corp.). The importance of optimizing the magnetic circuit was again emphasized. Kuhn also raised the issue of the need for further characterization of the material due to the dependence of physical properties on bias field, stress, drive, temperature, etc. investigations at Martin Marietta observed changes in resonance frequency (Young's modulus) with drive.

There was not a great deal of mathematical analysis or theoretical modeling of the material and its uses discussed. Edge Technology published and distributed an application manual generated by J. Butler of Image Acoustics, Hingham, Massachusetts, for the design of "Etrema terfenol-D" magnetostrictive transducers. At the Marbella meeting, G. Engdahl of Asea Brown Boveri, Vasteras, Sweden, discussed dynamic simulation in the design of magnetostrictive devices, yet his paper was more attuned to the complexity of the modeling rather than the actual modeling of devices.

The use of the material for actuator application in the nonmilitary arena such as in linear motors for accurate positioning, etc., seemed to be of interest to the majority of the attendees. Two very good papers as well as demonstrations were presented relative to precision displacement using terfenol as the actuator in moving a shaft to an accurate displacement. One of these was by L. Kiesewetter (Technische Universitat), and his colleague K.Y. Huang. The other was by R. Adolffson of SKF Nova, Göteburg, Sweden. There appears to be an excellent marriage to application here where high power, large displacements, and high temperature are a requirement. Demonstrations of actual prototypes were very well done.

Amorphous Alloys

Although terfenol was the major topic of discussion at the Marbella meeting, boron-iron-silicone amorphous ribbon was given substantial treatment. This piezomagnetic ribbon has a phenomenal coupling coefficient and gauge factor; it is also the most sensitive magnetostrictive material on the market and manifests outstanding physical properties with respect to strength and ductility. The major processing steps involve rapid quenching of the material in a gas or liquid environment. The material has applications all the way from transformer cores and sensors to cables and tire cords.

The Allied Corporation produces a version of this material under the trade name "Metglass." Considerable discussion was given to its strain gauge, torque transducer application, along with a fine demonstration. Strain gauge figures of merit with this material have been increased five orders of magnitude beyond those of conventional resistance strain gages. H. Savage of NSWC, White Oak, I. Osagawara of Unitika Ltd., Osaka, Japan, and A. Hernando of Universidad Computense, Madrid, Spain, all discussed the processing, properties, and application of the amorphous alloy.

Conclusion

This meeting was a success in informing a broad international community on the latest advances in piezomagnetic materials for both extremes of magnetomechanical transduction, high-power projectors, and ultrasensitive detectors. Bringing together the industrial and military community allows discussion of a broad range of requirements and encourages new ideas of application. There is no question as to the merits of the new materials and potential for substantial performance improvements in actuator and sensor design. There are still process improvements and chemistry that need to be done as should be expected with any new material. The industrial community with its tremendous market is probably better able to support this effort right now than the military. The presence of T. Murakami of Komatsu Ltd., who was representing the highest level of research in Japan is a strong indication of the visibility of this technology.

A compilation of papers from the conference may be obtained from Sensglas Terfenol AB, Research Park IDEON, S-223 70 Lund, Sweden, telephone Int + 46 46 18 24 40.

3/19/89

Sixth International Conference on Surface Modification of Metals by Ion Beams

by Graham K. Hubler. Dr. Hubler is a scientist in the Condensed Matter and Radiation Science Division at the Naval Research Laboratory, Washington, D.C.

The Sixth International Conference on Surface Modification of Metals by Ion Beams (SMMIB) was held at Riva del Garda, Italy, from 12 through 16 September 1988. The purpose of the meeting was to foster interdisciplinary research in applications of ion beams to metals. Both fundamental aspects of materials research and applications of ion beams to materials problems were encouraged. The surface modification techniques highlighted by the conference are ion implantation, ion beam mixing, and ion-beam-assisted deposition.

The meeting was organized by Professor Luis Guzman from the University of Trento. It attracted 155 participants and 114 papers. Twenty different countries (including Poland, Hungry, the USSR, and China) were represented. There were seven sessions on different subjects as listed below. Table 1 shows some of the target materials and ions discussed in the papers that were presented on metals. In this report, important highlights and impressions of the conference will be given. The proceedings will be published by Elsevier in 1989 in the Journal of Materials Science and Engineering (Eds., L. Guzman and G. Wolf).

Target Materials	No. of Presentation	Implants
pure iron	10	N^+, Ti^+, B^+ etc.
stainless steels	17	N^+, ti^+ etc.
Ti	5	N^+, B^+, 0^+ etc.
Ti-Al	3	N^+, B^+ etc.
Ti-Al-V	2	N^+, B^+
NiTi	2	N^+ etc.
TiN (Dynamical mixing)	5	
TiC (Dynamical mixing)	1	
Fe/Ti	3	Xe^+, Ar^+ etc.
Al	11	N^+ etc.
Ni, Cu, Cr	7	

Table 1. Target materials and implants in presentations at $SM^2 1B'88$.

History of SMMIB

The SMMIB conferences are independently organized by an ad-hoc international committee. The committee decides where and when the conference will be held and determines the technical program. The chairman of each meeting is responsible for the local meeting arrangements and fund raising for conference expenses. The conference was initiated in 1975 by R.P.M. Proctor and V. Ashworth from the University of Manchester Institute of Technology (UMIST), UK, and W.A. Grant from the University of Salford, UK. These meetings have been held in 1975, 1978, and 1981 at UMIST. In 1984, the conference location was the University of Heidelberg in West Germany, Professor G. Wolf, conference chairman. In 1986, it was held at Queens University, Kingston, Canada, Professor J. Whitton, chairman.

At this sixth meeting, the international committee selected the summer of 1991 as the time of the next conference and Washington, D.C. as the location. I and F. Smidt (also from the NRL) will be conference cochairman. It was tentatively decided that the following meeting would be organized by M. Iwaki in Japan in 1993.

The purpose of the first conferences in 1975 and 1978 was to bring together corrosion scientists and the ion implantation community in order to promote interdisciplinary research in the effects of ion beams on corrosion and oxidation. Prior to this conference, these had been no attempt to encourage such interactions. Since those two initial meetings the program has been moderately expanded to include other aspects of surface modification of metals by ion beams – fundamentals of radiation damage, phase formation, amorphization, and application to wear resistance and fatigue.

In the 1984 Heidelberg, meeting there was a successful effort to encourage papers on applications of ion beams in industry. Since then, the purpose of the meetings has been to promote interaction between scientists working on the fundamentals of ion-solid interactions and the increasing number of researchers pioneering the application of ion beams to materials problems. This emphasis is evident in the topics for each session of the conference that are listed below.

Surface modification of metals by ion beams began in the mid-1970's and as a technique and area for research continues to grow. The emphasis appears to be shifting from direct ion implantation to ion mixing and ion-beam-assisted deposition (IBAD). This trend will probably continue because, as I learned from private discussions with colleagues, many ion beam laboratories are starting programs in IBAD. The reasons are twofold: (1) much thicker layers can be produced by IBAD than with ion im-

plantation and (2) IBAD has been successfully applied to the manufacture of optical films, so the stage is set to apply it to other materials. This follows the history of ion implantation, which was developed in the early 1970's for semiconductor doping and later was applied to many other materials.

Program for the Sixth SMMIB Conference

The Sessions of this conference included:

- Fundamentals of surface modification by ion beams (high-dose ion implantation)
- Ion-induced surface phases (amorphization, interface mixing, quasicrystalline structure, phase transformations)
- Modification of mechanical properties (wear, fatigue, hardness, adhesion, etc.)
- Mechanisms and applications of ion-beam-assisted deposition
- Modification of chemical, electrochemical, and oxidation properties
- Thin-film metallurgy for microelectronic applications
- Industrial applications of ion beam techniques--methods and equipment
- Panel discussion: Industrial Applications of Ion Implantation Techniques

Professor H. Herman from SUNY-Stony Brook gave an opening plenary lecture commemorating the contributions of the late Professor W.A. Grant. Professor Grant was a founder of the conference and one of the pioneers of ion-beam induced amorphization of metals.

Fundamental Ion-Solid Interactions

P. Mazzoldi from the University of Padova, Italy, delivered an invited lecture entitled "Transport Processes in Solids During Irradiation." He discussed the processes of sputtering, enhanced diffusion, breakup of clusters of precipitate atoms, electric fields produced by ionization, and defect migration. These processes are common to all ion beam processing of materials. This is one of the first papers to include surface modification mechanisms of cluster breakup and electric fields in such a review. R. Kelley, IBM Yorktown Heights, reviewed the effects of sputtering and segregation on the composition changes occurring during ion bombardment. It is clear from this work that simple models of the surface composition based upon transport theory or Monte-Carlo codes will not yield the correct answer for the surface composition. Many contributed papers discussed effects produced during bombardment such as second phase precipitation, and the temperature dependence of phase formation.

A definitive lecture on glass formation in metals by ion irradiation was given by P. Ossi from CESNEF, Milan, Italy. He gave new insight regarding a model for prediction of glass transitions which depends upon complicated interplay of temperature, nature of the material, and ion species and energy. Several contributed papers repeated this theme on specific systems including Fe-Al, transition metal pairs, Fe-Pd, Ni-B, Mn-Al, Ni-Ti, and Ni-Al.

Ion Implantation of Steels

A landmark paper was given by R. Leutenecker from the Franhofer Institute in Munich. Over the years there has been a great deal of contradictory evidence on the phases formed in N-ion-implanted steels and the relationship of the phases to wear resistance. Leutenecker and coworkers have done an enormous microstructural study covering many steels at different implantation temperature and have sorted out many complicated phase transformations which take place. This information allows for the first time the prediction of the microstructure produced by N implantation of steels, and therefore, optimization of the process. Contributed papers consisted of discussion of N implantation of steels, TiN films on steels produced by ion mixing, friction and wear behavior of N- and Ti-implanted steels, fatigue of Ti alloys, etc.

Ion Implantation of Ceramics

Carl McHargue from Oak Ridge National Laboratory described hardness increases and decreases produced by ion implantation of the ceramics alumina and silicon carbide. Higher rupture strengths are produced and the remarkable effect was demonstrated that ion implantation can greatly change both the hardness and modulus of ceramics. This work is important because it could spur the revisitation of many applications of ceramics that were abandoned because of surface-flaw-generated failure. Ion implantation, especially at high energies, can reduce or eliminate microscopic surface flaws which greatly diminishes the probability of early failure.

Ion-Beam Assisted Deposition

The leaders in the development of IBAD technology for optical coatings have chiefly been located in the US. It is clear from this conference, however, that Japan will lead the world in development of the technology for industrial processing of metals, ceramics, polymers, etc. M. Iwaki from Riken in Japan reported the first application of IBAD TiN in an industrial process (coating of electric razor screens), and since then the Japanese have begun several other applications (coating of SiC ceramics). At the SMMIB conference in 1991 I that expect Japan will dominate the papers given on IBAD. According to Iwaki, there as an assessment in 1985 by the Ministry of International Trade and Industry (MITI) that ion-beam processing of materials would have many commercial payoffs in the 1990's. Programs were implemented to ensure that Japan would play a role and, if possible, dominate the field. An overview of the funding, presented

privately to me by M. Iwaki, is listed below, the programs began in 1986 and 1987:

- RIMES (Research Institute for Metal Engineered Surfaces): PVD, CVD and Ion Beams – $50 million, 7 years
- AMMTRA (Advanced Materials Processing and Manufacturing T chnology Research Association [Nissin, Hitachi, and other industrials]): Ion Beam and Eximer Laser Processing – $50 million, 7 years
- ARTP (Advanced Research Technology Project): double and triple beam experiments – $100 million, 5 years
- IEC (Ion Engineering Center, Osaka) – $35 million, 5 years (includes the ion beam service center ion micromachining project)

I gave an invited lecture, "Fundamentals of Ion Beam Assisted Deposition," and a second talk on IBAD was given by Jerry Cuomo from IBM Yorktown, entitled "New Compound Synthesis by IBAD." I received 35 preprint requests, many from people from industry who were present but did not give papers. Only eight papers on IBAD were given at the meeting. The high ratio of preprint requests to papers given is direct evidence of growing interest in IBAD.

Chemical Effects

Dr. Ensinger from the University of Heidelberg, West Germany, reviewed his work on the corrosion behavior of ion-mixed alloys and IBAD coatings. This was only the third paper in this area ever published. Simple metallic coatings produced by IBAD (e.g., Al on Fe, Pt on Ti) gave better results than PVD or ion implantation because of the high-adhesion, high-density films (no pin holes). This simple concept of high-quality metallic coatings on materials with poor corrosion resistance is not new, but the superior properties of IBAD or ion-mixed coatings makes the simple solution workable. P. Natishan from NRL, Washington, presented a paper entitled "Corrosion of Ion Mixed Al Alloys." Professor Wolf pointed out that Natishan's work is a good example of how ion implantation can be used to investigate fundamental corrosion mechanisms. By implantation of selected ion species, Natishan was able to prove that the pitting of pure Al could be controlled by changes in the surface charge. When the surface charge is negative, Cl^- ions are repelled by the surface and no pitting occurs; whereas, when the surface charge is positive, Cl^- is adsorbed and pitting is severe.

Surface Modification Research in China

A lecture titled "Ion Implantation in China in the Nonsemiconductor Field" was delivered by Dr. Zhang from the Institute of Low Energy Nuclear Physics in Beijing. He indicated there are 15 groups in China in the nonsemiconductor field but only nine implanters among them. They are building their own equipment to get by. As an aside, I recently found that seven medium-energy NEC Pellitron accelerators have been sold to laboratories in China, which indicates that they are serious about creating ion beam facilities.

Applications and Equipment

J. Hirvonen from Spire Corp., Bedford, Massachusetts, delivered an invited lecture, "Ion Beam Processing for Industrial Applications." Spire has three implanters running three shifts to meet demand for the treatment of tooling for industry, and they have an IBAD program under development. He said that notable successes in application of ion implantation in industry include: the implantation of tools in the tool and die industry which improves wear and corrosion by factors of 10, the implantation of bearings for the space shuttle rocket engines, and the implantation of Ti alloy medical prosthesis implants (artificial hip and knee joints, etc.). J. Conrad from the University of Wisconsin ended the meeting with a presentation, "Plasma Ion Sources for Ion Implantation." The workpiece to be implanted is "immersed" in a plasma and held at a potential of up to 100 kV. Ions are extracted from the plasma such that implantation occurs around the entire piece. This technique has the advantage of high "throwing power" and promises to significantly reduce the cost of ion implantation processing.

Panel Discussion

The meeting ended with a panel discussion on industrial applications of ion implantation techniques. The panel noted that there are now five ion beam service centers in Japan plus five more associated with companies for internal work (Hitachi, Nissin, Osaka, World Engineering, ULVAC), four in the US, two in the UK, one in Germany, and one in Denmark. This is to be compared to 4 years ago at the Heidelberg conference when there were four in the US and one in the UK. Other interesting facts gleaned from the discussion is that the Jaguar racing team has ion-implanted cam shafts in their race cars (Jaguar won the Le Mans endurance race last year) and that Daimler-Benz has purchased an ion implanter and hired people to staff a program. Toyota has ion-implanted turbo-charger parts in the field. By contrast, GM and Ford are aware of ion beam technology but do not have research programs.

Final Impressions

I was left with the impression that ion implantation as an industrial process is now firmly established, but that IBAD has a much greater potential for commercial development and will likely surpass ion implantation in

commercial development and will likely surpass ion implantation in commercial sales within 2 years. As for the future of the field of surface modification by ion beams, my impressions were that there are many areas still virtually untouched. For example, there have been few papers published on the ability of IBAD to produce very thick films of metastable materials, multilayers and superlattices, graded interfaces, epitaxial films, or multifunctional coatings. Also, the study of gas-solid reactions during ion bombardment is in its infancy. These are areas for future growth in fundamental research.

3/19/89

MATHEMATICS

The Mathematics and Computation of Deforming Surfaces

by Richard Franke. Dr. Franke is the Liaison Scientist for Mathematics and Scientific Computing in Europe and the Middle East for the Office of Naval Research European Office. He is on leave until September 1989 from the Naval Postgraduate School, Monterey, California, where he is a Professor of Mathematics.

This conference, sponsored by the Institute of Mathematics and its Applications (IMA), was organized by Drs. J.C.R. Hunt, D. Dritschel, and R.J. Perkins of the Department of Applied Mathematics and Theoretical Physics (DAMTP) at the University of Cambridge. It was held at the University on 19 and 20 December 1988. Although in the past IMA has sponsored several meetings concerned with surfaces (see ESNIB 89-04:23 for a report on the immediately previous one), this is the first that was devoted entirely to deforming and moving surfaces. It was a small meeting, with fewer than 15 talks being given – some of which were impromptu in the sense that they were not on the program – and an attendance of about 35 persons. Included in the program was a visit to DAMTP with demonstrations of some of the experimental and computational facilities. Although the meeting was small, there was an amazing variety of discussions concerning quite different problems involving surfaces, encompassing shells and curved elastic panels, balloons, fluids and bubbles, flames, and fabrics. The great variety of possible behavior by deforming surfaces are suggested by considering the first and last of these. I will describe in some detail those papers that I found particularly interesting.

Fluids and Bubbles

In a paper entitled "The Rise and Distortion of a Two-Dimensional Gas Bubble in an Inviscid Liquid," G. R. Baker (Ohio State University, visiting at the University of London) discussed a study which involved the evolution of an initially circular bubble between two glass plates that were 0.95 cm apart. Experimental results were available for comparison (Walters and Davidson, 1962). In the experiment, an air bubble was released and photographed. It was assumed the fluid was incompressible and that the bubble was two-dimensional and initially circular (the dynamics of air being ignored). A boundary integral method was used, reducing the problem to a Fredholm integral equation of the second kind. The solution for the boundary location was approximated using cubic or quintic splines, and the resulting equation solved by iteration. Because a time integration process was involved, a good initial guess was available. The time integration was performed using the fourth-order Adams method. The calculated solution indicated the bubble is deformed by a jet in the center of the back (bottom) with two lobes forming on either side of it, the jet rising upward to be considerable taller and thinner than shown in the experimental pictures. The inclusion of surface tension only partially alleviated this. The calculated evolution of the surface was quite sensitive to initial perturbations of the circular shape, and with high enough wavenumber, Rayleigh-Taylor jets formed on the upper surface (but not in the experiments). Although the computational and experimental results are similar, Baker concluded that two-dimensional inviscid flow does not account for all of the effects necessary to properly model the bubble.

D. H. Peregrine (University of Bristol, UK) spoke about his work on steep unsteady water waves. He models breaking waves (up until the "splash point") using potential flow, using boundary integral method with periodic boundary conditions. This reduces the problem of calculating the inviscid, incompressible, irrotational mo-

tion of the body to the evaluation of its surface, hence making possible the numerical calculation by a discretization of the surface alone. It is necessary, however, to use a fairly large number of points on the surface. The Cauchy integral theorem is used to obtain the equations used for the complex velocity. This results in equations which can be solved iteratively, and from which higher order (time) derivatives can be calculated for use in a Taylor series method in time. It was necessary to use high-order approximations in both space (tenth order was used) and time (seventh order), with a high density of points at the top of the wave (see Dold and Peregrine [1986] for further details). In some instances smoothing was used in the space domain for stability purposes (to overcome the use of a too-large time step).

The goal of the work of Peregrine and his colleagues and students is to determine why and how waves break. Using a solitary wave plus a small perturbation for initial conditions, their calculations show that the eventual evolution is to one of two types, depending on the perturbation: either the wave breaks rather quickly, or it evolves back to the solitary wave after a considerably longer (more than 10x) time. Peregrine also discussed some results for shallow waves over a submerged semicircular breakwater. In some cases, depending on the depth and size of the breakwater and the size of the wave, there is a smaller, backward-breaking wave just downstream of the breakwater, while in other cases only the solitary wave breaks, or there is no breaking (Cooker and Peregrine, 1988). The breakwater results have been observed experimentally. These calculations were all run on a personal computer with 80286/80287 chips, some runs taking on the order of an hour to complete.

David Dritschel (University of Cambridge, UK) presented a paper entitled "Contour Dynamics/Surgery." Contour dynamics is a method of solving problems of inviscid, incompressible two-dimensional vortex flows involving 4-5 orders of magnitude of spatial scales. It is a Lagrangian method in which the problem is formulated as an integral over the vorticity values (the integral becoming a sum with the assumption of piecewise constant vorticity) of interest, of a contour integrals around the vortices. Problems with contour dynamics occur with rapidly increasing curvature and lengthening perimeters. To deal with these, an adaptive node distribution/redistribution is used on the contours, where the nodes are dependent on the nonlocal curvature (the dependence is on curvature at all nodes as well as the distance to the nodes, the precise formula being empirical). Cubic spline interpolation is used between nodes. The "surgery" part of the algorithm comes into play to limit the range of spatial scales. The operations here consist of inserting a corner when curvature becomes too great, splitting very thin contours, and connecting contours which become close together. The contribution of such features to the overall dynamics is very small, so their loss is insignificant but, as a result, the calculation can be continued for a very long time. The primary use of this scheme is to compute the large-scale structure, which the small-scale structure does not influence very much, and hence can be surgically removed. The scheme, with eight contours, has been compared with a pseudo-spectral calculation on a 1024 x 1024 grid done by Bernard Legras. The two calculations give essentially the same results. It should be noted that the spectral method is an Eulerian method, whereas the contour dynamics/surgery method is Lagrangian. At high Reynolds numbers, the method can capture very steep gradients successfully, according to Dritschel, and in this instance the calculations are much cheaper than for the spectral method. A forthcoming joint paper with Legras will give a detailed comparison (Dritschel and Legras, 1989).

Balloon stability

"Stability of the Endeavor Balloon" is the title of the paper given by C. R. Calladine (University of Cambridge). The Endeavor balloon is the helium-filled balloon in which Julian Nott and a colleague intend to circumnavigate the world. The design is new, incorporating a number of inextensional Kevlar tapes running in the longitudinal direction, with the fabric being much fuller so that when inflated the fabric bulges out between the tapes, achieving low stress in the fabric for a given internal pressure. To attempt to alleviate the diurnal pressure variations, it uses a double bladder, the inner one filled with air, which is used to keep the pressure constant. This is different than hot air balloons, which have zero pressure at the bottom and linearly increasing pressure to the top of the balloon. Consequently the Endeavor balloon has a much more (top to bottom) symmetrical shape than the inverted onion dome shape of hot air balloons. Unfortunately, Nott has had some problems, among them diplomatic and financial, but perhaps the most disheartening and unexpected occurred when a prototype balloon was first filled with helium. Nott discovered that instead of filling out into a nice symmetrical shape, the balloon did not completely unfold – several of the Kevlar tapes and the associated fabric hung down into the center region of the balloon. He discovered experimentally that this problem could be solved by removing some of the Kevlar tapes and the associated wedge-shaped fabric sections. About this time, he also approached Calladine about the problem. Calladine discovered that the phenomenon could be described by a simple two-dimensional model based on the idea that for stability, the volume of the balloon must be a maximum with respect to small perturbations in its shape. In the simplified case, this leads to a rectangular area with bulging circular caps of constant arc length. His analysis gave an inequality that

had to be satisfied for the area to be a maximum. The angle of the caps could then be related back to the number of segments for the balloon, yielding a maximum number of panels, or longitudinal tapes for which the configuration would be stable when filled. Although the analysis was not definitive in the sense that it gave the answer as to the exact configuration that the balloon should have, it did serve to explain the essentials of the phenomenon by a simple analysis.

Sheet Metal Stamping

A.A. Ball (with R.J. Cripps, both from University of Technology, Loughborough) presented a paper titled "Overcrown Prediction for Drawn Panels." The problem is particularly acute in the automobile industry, where most of the sheet metal parts are stamped (or drawn) using press tools. The shape of a sheet metal piece or panel is not exactly that of the tool which made it because the panel tends to have an elastic spring-back. If the spring-back is too great, the panel will not properly match with the adjoining part. The problem for the toolmaker is to predict the amount of spring-back and then compensate by building the tool to be overcrowned. Many of the "oldtimers" in the industry have the ability to guess closely how much overcrown should be built into the tool, but it is a dying art, is time consuming, and the guess may need to be corrected. More importantly, the overcrown calculation represents a "missing link in the CAD/CAM chain," to quote the authors. The design of panels such as the roof, hood, or trunk lid is carried out using a parametric form, perhaps consisting of several patches. The cutter paths for making the punch tools are ideally generated from this representation. The goal of Ball and Cripps' project was to develop a prediction system for the mount of spring-back which could then be used to correct the cutter paths when making the press tools from the design information.

The first phase of the project was to investigate the processes involved in the procedure, such as data communications, patch blending, and identifying working tolerances. One of the early discoveries was that geometric "flaws" in the design in the nature of oscillating and discontinuous higher order derivatives were exaggerated by the panels. Thus the magnitude of the spring-back was dependent on the quality of the surface definition: low quality not only made spring-back larger, but harder to predict, while high quality lead to easier predictions. The second phase resulted in the following procedure, which is being adopted by the manufacturer: (1) the panel geometry from the design system is smoothed using C^1 biquintic patches; (2) the overcrown is defined, based on empirical predictions from the shape of the panel; (3) the tool is produced; (4) the panel obtained from it is digitized; (5) the obtained panel compared with the desired panel. It has been found that for some panels, smoothing is all that is required, while in other cases, overcrowning is necessary. It is interesting to note that in many cases the problem was solved, while in others it was alleviated by "proper" smoothness being incorporated in the definition of the panel.

Combustion

In their paper, "Extraction of Spatial Statistics from Experimentally Visualized Cross Sections of a Turbulent Flame," techniques used to analyze turbulent flame surfaces were discussed by R.E. Britter and K.N.C. Bray (with T.C. Chew, all from University of Cambridge). They obtained the experimental data as follows: A grid was placed over a Bunsen burner, oil was injected, and a (two-dimensional) picture of the resulting flame then obtained by laser tomography. The picture was digitized and analyzed for the flame boundary. For this purpose they used an eight-connectivity "intelligent bug" algorithm. By superimposing many images, they obtained a mean flame boundary, and then achieved a probability distribution of such information as spatial crossing lengths and frequencies, and orientation of local flamelets. Superimposition of many images from this probability distribution gives an image that does look very flamelike. More turbulence results in more convoluted shapes, as would be expected. An interesting observation has been that the crossing angle between the mean and individual realizations is quite uniform over a wide range of conditions. Modeling the flame surface by fractals yielded a boundary dimension of about 1.2, from which the authors concluded that the boundary of the three-dimensional surface would be about 2.2. The ultimate goal of the authors is to bring together the modeling, experimental, and computational parts of flame theory. A paper has been submitted (T. Chew, et al., 1988).

Fabrics

The mathematical and computational modelling of fabrics in the fashion industry is becoming necessary in order to remain competitive and responsive to market pressures. D. W. Lloyd (University of Leeds, with coauthors A. H. Norton and R. Postle, University of New South Wales, Australia) addressed this problem with their talk entitled "Approaches to Modelling the Mechanical Properties of Fabrics and the Representation of Fabrics as Flexible Surfaces Using Differential Geometry." Modeling fabrics is a formidable problem, and although finite element methods have been attempted, the properties are very different from the materials to which these methods have traditionally been applied. In particular, fabrics are nonlinear, compliant, anisotropic, bend freely, and have Poisson ratios > 1. Because of

these complications, Lloyd and coworkers are using a differential geometry approach. They work with three-dimensional parametric definitions of the material shape, and impose stress-strain relations and compatibility conditions. The fabric is modeled using quadrilateral and triangular (degenerate quadrilateral) patches. Their present goal is simply to gain new understanding of the behavior of fabrics. The ultimate goal of the industry is to computationally generate the precise image of the "provocative folds and seductive flairs" of a garment worn by a model as she walks onto the stage and twirls about. Lloyd assures us this is far in the future, but one cannot help but wonder which fashion house will be the first to place an order for a Cray 3!

J. W. S. Hearle (coauthor, Jafar Amirbayat, both of the University of Manchester Institute of Technology) spoke on complex buckling of textile fabrics and other flexible sheets. Hearle notes that buckling into smooth, rounded folds is an essential feature of textile fabrics – another explanation why paper, which collapses into point and line discontinuities, has never been popular for garments. He then described his investigation into one of the simplest problems, that of the buckling of a circular, isotropic, linear elastic sheet, subject to radial inward deformation at three equally spaced positions on the circumference. By partitioning the sheet into an inner dome of double curvature and an outer dome of (three) folds of single curvature, and minimizing energy, a prediction of the shape of the deformed surface is possible. He then discussed some of the problems awaiting solution, including the more general double-curvature problems (which are very important in textiles), draping (tablecloths, skirts), buckling of tubes (sleeves, legs), waving (flags), formability, and laying and cutting problems. Further problems exist in fabric construction and determination of performance in use. While the nature of these problems is undoubtedly less vital than that for most problems I know about, the intellectual challenges certainly seem to be available.

Conclusions

Even though this was a very small conference, both in terms of speakers and attendance, it was a meeting which treated an important topic – one on which many interesting papers were presented. The Institute for Mathematics and its Applications is a large (primarily, but not exclusively, British) organization, which professes to want become larger and more international. This meeting was somewhat typical of their meetings with which I am familiar in that it seemed to be rather provincial in its organization. This one was organized at Cambridge, and many of the speakers were from Cambridge – only two from continental Europe, and one from the US (visiting at University of London). As I have noted, it was a fine program, but surely there are many other mathematicians in the UK and other European countries who could have participated. Whether they did not participate because they did not know of the meeting or because the provinciality I mentioned, I don't know. At the least, I would welcome wider dissemination of information concerning IMA meetings.

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3/21/89

Some Numerical Analysis Work in the Department of Applied Mathematics and Theoretical Physics, University of Cambridge

by Richard Franke.

I was invited to visit the University of Cambridge by Professor Michael J.D. Powell. Powell is very well known for his work in optimization and in approximation theory, the author of a book on approximation theory and of numerous papers appearing in scientific journals. We discussed some of the recent work of his group as well as some ideas for further work.

Powell is perhaps best known for his work in optimization. His recent work (Powell, 1988) has resulted in an algorithm for linearly constrained optimization of a differentiable function. The algorithm is very reliable and suitable for problems which have many linear constraints that come from discretization of continua. The key to the algorithm is in the treatment of inequalities when choosing the search direction. Two extreme techniques for this are to take account of all constraints, or to use an active set method that satisfies selected constraints as equations with the remaining constraints being ignored. Powell's method uses an intermediate scheme that treats all inequality constraints with "small" residuals as being satisfied with zero right hand side so that the search direction chosen is not toward the boundary of such inequalities. The definition of what quantity is "small" depends on a parameter, τ, which decreases during the iterations to become something on the order of 100 times the machine epsilon (machine epsilon is the smallest number which when added to 1 gives a result bigger than 1). The effect of limiting the search direction is to allow relatively long steps since directions toward nearby boundaries are not allowed. The Fortran implementation of the algorithm (Powell, 1989) was extensively tested, including the use of small τ (which results in essentially ignoring the principal idea of the algorithm), and compared with existing algorithms.

Radial Basis Function Approximation of Multivariate Functions

A second topic of investigation by Powell and his students is radial basis function approximation of multivariate functions. This work may be motivated by the need to approximate such functions in optimization theory. Some results presented at a conference by a student of Powell's, I. R. H. Jackson, have been reported on previously (see ESNIB 89-04, p. 25), so I will confine myself to later work.

First, recall that radial basis function methods involve the use of a function of distance, $\Phi(d)$, in an approximation of the form $\Sigma a_k \Phi(||x-x_k||)$. It is also possible (and desirable) to include some low-degree polynomial terms in the sum. The coefficients, a_k and polynomial coefficients, are determined by interpolation conditions and some precision conditions related to the polynomial terms. The approximation has mostly been used in the case of scattered data in two and more dimensions since regular data are amenable to efficient treatment by methods such as tensor product splines. Even so, the fitting power of any method can be investigated by considering equally spaced data, and this is the approach of Powell and his group.

Powell and his group's initial results were obtained through the use of quasi-interpolation on infinite grids. Their use of Fourier techniques has allowed the derivation of the Fourier transform of the cardinal interpolation function (a cardinal interpolation function has the property of taking on the value 1 at one interpolation point and the value zero at all other interpolation points). The decay properties of the cardinal function can then be inferred from the differentiability properties of the transform. The interesting results are that for even dimensional spaces the thin plate spline function, $\Phi(d) = d^2 \log d$ yields exponential decay, while in odd dimensional spaces the linear and cubic functions yield exponential decay. In the other cases the decay is only algebraic. For the multiquadric function $\Phi(d) = (d^2+c^2)^{1/2}$ $(c \neq 0)$ the decay is algebraic, $O(d^{-2n-1})$ when n is even, and $O(d^{-3n-2})$ when n is odd. The reciprocal multiquadric has order of decay two less in even dimensions and four less in odd dimensions. Even though the decay of multiquadrics is algebraic, Buhmann and Powell (1988) show that the coefficients of the low-order terms are small enough so that the decay down to around 10^{-6} is nearly as rapid as for thin plate splines, for which the decay is exponential. This is verified computationally in a number of examples in two and three dimensions.

Because the multiquadric method does not have exponential decay, but as a practical matter does decay to small values rapidly, some computations in three dimensions were made comparing the decay of the cardinal function for the multiquadric with $c = 0.5$ and $c = 0.1$ with those of the linear and cubic basis functions. The linear cardinal function decays most rapidly to moderately small values (again, say 10^{-6}). However, this function is not differentiable at the data points while the multiquadric function is infinitely differentiable for $c \neq 0$, and only a slightly larger region of values of magnitude than 10^{-6} occurs. For reasonable values of c, the multiquadric cardinal function decays to 10^{-6} faster than the cubic cardinal function.

The rapid decay rates of the radial basis function methods lead to several topics for investigation:

- Since data sets are generally finite, the questions of how to handle boundaries in such a way as to not compromise the rate of convergence arise.
- Even though data sets are finite, they may be very large. The rapid decay rates lead to the possibility of being able to approximate the coefficients in the interpolation function locally. By iterating the process on the residuals, an efficient iterative method may result. Such a process might be considered as a preconditioner.
- How does the inclusion of polynomial terms affect the convergence rates?
- Can the convergence results be extended to the non-uniform case (but with some quasi-uniformity constraints), and especially with a finite amount of data?
- Will the use of parallel computers be able to overcome the significantly increased complexity of radial basis

function approximations compared to tensor product splines so that they are a viable alternative when data occurs on a grid?

In a slightly different vein, a student, B. J. C. Baxter (see Baxter, 1988), has investigated the invertibility of matrices of the form $A_{ij} = ||x^i - x^j||_p$, for arbitrary distinct points x^i in n-space. While some of the results would follow readily from powerful theorems already proved, Baxter's work is interesting because his results follow from elementary arguments. Basically the results are that for $1 < p \leq 2$ the maxtix is always invertible, while for $p > 2$ a set of points exists for with the matrix is not invertible. According to Baxter, Will Light, Lancaster University, has pointed out that for $p = 1$, the matrix is singular when the point set is the vertices of the unit square. The results follow from being able to express the matrices as distance matrices (i.e., the matrix with the form of A for $p = 2$) for some other points y^i. These results are not necessarily of any practical value, since it is not likely to want to measure distance in p-norms other than the usual Euclidean norm, $p = 2$, but the elementary proofs make the paper interesting.

Comment

Powell and his students are involved in some very interesting theoretical and practical work in optimization and approximation theory. The optimization work has resulted in a powerful algorithm which is available as a Fortran code. The radial basis function theory is still primarily of theoretical importance, but is necessary to gain an understanding of the approximation power of such schemes, from which powerful and practical algorithms may follow.

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3/13/89

MECHANICS

13th International Seminar on Modal Analysis

by David Feit. Dr. Feit is the Liaison Scientist for Acoustics and Mechanics in Europe and the Middle East for the Office of Naval Research European Office. He is on leave until January, 1990 from the David Taylor Research Center, where he is a research scientist in the Ship Acoustics Department.

For more than a decade the Katholieke Universiteit Leuven, in Belgium, has been sponsoring a series of seminars devoted to modal analysis and structural dynamics. This year's meeting, the 13th International Seminar on Modal Analysis, held from 19 through 23 September 1988 was dedicated to the memory of Professor Snoeys, the founder and driving force behind the series, who died in December of 1987.

The series closely parallels the International Modal Analysis Conference Series (IMACS), which is also held on a yearly basis. The IMACS meetings are usually held one year in the US and the next year in some foreign locale – Europe or the Far East – whereas the Leuven series has always been held in Leuven. The fact that there are two series of meetings, each held on a yearly basis and typically with an increasing attendance, attests to the growing and continued interest of engineers and scientists in this rapidly expanding field.

This particular meeting was set up as a combination of a 2-day course on the basics of modal analysis and concluded with a 3-day seminar where invited and contributed papers were presented.

In parallel with the seminar, an exhibition of modal-analysis-related equipment took place. Major vendors, including a number of US companies, participated in this exhibition. The exhibit gave participants the opportunity to learn about the latest products in the field of modal analysis technology.

There were 21 invited papers and 56 contributed papers presented in six plenary sessions, and six sets of three parallel sessions, respectively. More than 150 individuals, mostly from Europe, with a smaller number from the US and the Far East, participated in this meeting. All

papers presented are available in a three volume set of proceedings; more detailed versions of some of the papers may appear in forthcoming editions of the Journal for Mechanical Systems and Signal Processing.

Amongst the topics discussed were:

- Parameter estimation theory
- Trends in instrumentation and software
- Analytical analysis techniques
- FE model updating
- Structural nonlinearities
- Fatigue life estimation
- Active vibration and noise control
- Acoustic analysis techniques
- Case studies of modal analysis techniques.

In the remainder of this article, I shall primarily confine my discussion to some of the papers presented in the plenary sessions but with an occasional foray into the contributed sessions, especially those dealing with acoustical applications.

The Past and Future of Modal Analysis Applications

In the opening plenary session, after Professor J. Peters (Katholieke Universiteit Leuven [KUL]) dedicated the meeting and reviewed the scientific legacy of Professor Snoeys, Professor D.L. Brown (University of Cincinnati, Ohio) traced the developments and uses of spatial domain concepts in the measurement and estimation of modal parameters. The methods discussed included forced normal modes, Ibrahim's time domain, and direct parameter estimation techniques among others. In his conclusion, he pointed out the current trend to making simultaneous measurements over the entire extent of the structure with very large amounts of information available, and the need to drastically condense this information using modern signal processing techniques. The spatial domain data dramatically improves the parameter estimation procedures. Because of Brown's pioneering role in the early applications of modal analysis, this lecture served as an excellent review and starting point for the conference.

P. Sas (KUL) reviewed the fields of application of modal analysis techniques with a special emphasis on the KUL's contributions. The work at Leuven, following the inspiration of Professor Snoeys has been mainly directed towards developing tools to improve the structural dynamic behavior of mechanical systems through the design process. After describing the fantastic growth in the field during the past decade in terms of users and software and hardware suppliers, he offered some sobering thoughts as to the possibility of an end to the booming growth, especially in the modal testing field. He sees the future as one in which new developments might principally be limited to aesthetic features such as improvements in graphic capabilities and the marketing of new products primarily as replacements. He also pointed out some of the important limitations of modal testing related to measurement accuracy and model validity in terms of the test boundary conditions or environmental parameters as contrasted with actual conditions on the system in practice.

H. Vold (SDRC, Inc., Milford, Ohio) gave a short talk on the numerical conditioning of some modal parameter estimation methods that make use of frequency domain characteristic polynomials. In particular, he concludes that frequency bands with less than ten modes only should be analyzed using such a procedure. He suspects that multireference matrix polynomial methods are much less sensitive because they do not compress the data so extensively.

The final invited talk of the first day was presented by M. Merguey (LMS International, Leuven) who discussed the significance and benefits of a large computer-based dynamic analysis system in two automotive research laboratories – those of Italiana Keller in Santhia, Italy, and Renault's Acoustic Laboratory in Rueil Malmaison, France. Specific applications examined included a study of the acoustic characteristics of a spark ignition engine, and the improvement of the low-frequency acoustic and vibration environment of a large truck cabin.

Optical Techniques in Modal Analysis Testing

Two contributed papers that discussed the use of optical techniques in modal analysis testing provided information on some fresh approaches to modal testing. The first paper, by B. Rediers and R. J. Allemang (University of Cincinnati, Cincinnati, Ohio), gave details of a feasibility study using video imaging techniques in an experimental modal analysis data acquisition system. Instead of mass loading a lightweight structure by adding a large number of accelerometers, they propose adding reflective markers at measurement locations and recording the motions of the object using a video recorder. The data is then passed to a proprietary video processor (developed by the Motion Analysis Corporation) which performs data reduction and display or printout. For systems that comply with the requirements of low frequency and large amplitude displacements,the results obtained are comparable to standard techniques.

In another study, K. Wyckaert, H. Magits, and P. Sas (KUL) used time-averaged electronic speckle interferometry to make dynamic measurements on a very small and lightweight object. These measurements were compared to the results of finite element modeling of the same structure, which are then used in the design optimization of the structure. Because of the continuing trend in miniaturization of high-technology products, such measurement tools will become more necessary and useful in the future.

Numerical Modeling for Noise Analysis

There were a number of papers presented on the use of numerical modeling for acoustics and vibrations analysis. J. Coyette, P. Guisset, and E. Dejehet (Dynamic Engineering NV, Heverlee, Belgium) gave a general talk on the use of boundary element method techniques in solving problems of noise source identification in vehicle acoustics. Their approach has been implemented in a program called SYSNOISE which is currently being marketed by Dynamic Engineering. There are also other companies both in Europe and the US which have similar programs available on a commercial basis. (I find this trend toward the commercial marketing of software dedicated to structural acoustics applications more prevalent in the European market than in the US.)

S.J. Garton, J.M. O'Keefe, and J.T. Matthews (SDRC Engineering Services Ltd., UK) applied one of SDRC's calculation programs to a combatant vehicle hull and compared the results to test measurements. The predicted noise and vibration levels compared favorably with test measurements in the 0- to 256-Hz range. The interior fluid pressure was modeled using a finite element code called SDRC/SUPERB. In this particular application, there was no modeling of the external acoustic pressure field.

In the final paper of this session, K.R. Fyfe (Dynamic Engineering NV, Heverlee, Belgium) advocated the use of boundary element techniques in frequency response studies. The direct response solutions derived from BEM techniques are used with curve-fitting procedures of modal analysis to obtain the acoustic modal parameters of the system which, in this case, consisted of a car interior. BEM techniques are thought to be advantageous because of simplified meshing requirements as compared to FEM approaches.

Coupling of Structures Using Measured FRF's

J. Leuridan (LMS International, Leuven) discussed improved techniques for calculating the frequency response function (FRF) of a total structure using substructure FRF's. The techniques that were advocated here include the use of a pseudo-inverse for solving the coupling equation, and the preprocessing of the component FRF's by symmetrization and smoothing. On numerically simulated data, these techniques significantly improved the results. However, when used on experimental results which were for higher frequencies and where the response was primarily nonmodal, the results were less encouraging. This study was performed under contract for a research group associated with the French Navy.

Applications to NonLinear Systems

G.R. Tomlinson (Heriot-Watt University, Edinburgh, UK) described the use of higher order frequency response functions in the analysis of nonlinear systems. Such response functions can indicate the existence of nonlinear modal interaction, frequency modulations, and harmonic distortion. The methods used for obtaining these higher order FRF's were described and the results discussed for simulated data. Actual experimental results for a preloaded beam clamped at both ends (referred to in the discussion as "encastre ends") with an initial deflection were also presented and discussed. A comparison of the current method to two other procedures – the NARMAX method (Billings, 1988) and the Restoring Force Surface method – concluded the discussion.

Concluding Plenary Session

C. Stavrinidis (European Space Agency, Noordwijk, the Netherlands) presented his view on the adequacy of modal analysis, test, and coupling techniques in space craft applications. My impression is that he sees the need for improvement in a number of areas. With regard to modal updating, he is critical of those practices wherein only the stiffness matrices are updated. In his view, this approach has no apriori validity. As an example for one-dimensional longitudinal vibrations, he has shown that it is the mass matrix that requires the updating. In general, he finds that modal updating procedures that have been proposed are unsatisfactory because fundamental structural constraints are not accounted for or even considered. He also questions the accuracy of damping that is measured by modal testing. To an outsider to the field such as myself, this talk gave the impression that much more analysis and investigation is required before modal analysis techniques can be used with complete confidence in the practical engineering environment.

The state of the art in the quantification of noise and vibration sources was presented by G. Desanghere (Dynamic Engineering NV Heverlee). He reviewed the techniques of multiple-input-output systems such as determination of the relationships between different input signals, and the identification of excitation forces on a structure. The force identification problem requires the inverse of the frequency response function, which has many difficulties, and a number of techniques are proposed to overcome them. Although these techniques are still in the development phase, a number of successful applications were mentioned.

The conference was concluded by the final invited talk of H. Van Belle (BN Spoorwegmaterielen en Metalconstructies, Brugge, Belgium) in which he discussed the

potential usefulness of the Cayley-Hamilton theory in the field of sensitivity analysis. Unfortunately, this endeavor did not prove to be useful.

Concluding Remarks

This conference proved to be very useful to me as a nonspecialist in the field of modal analysis. During the course of the meeting, one quickly became aware of the current applications of the technique, and of the problems that the technique or approach must overcome as it becomes more widely used in engineering practice. There was an excellent balance of survey-type papers, examples of application, and discussion of new developments.

Having never attended a modal analysis conference before I cannot really address the issue of originality of the papers presented. However, given the fact that there are at least two international meetings of this type every year, I must imagine that regular attendees of such meetings have been exposed to much of the information before, and may have come away from the conference with somewhat different opinions than I have expressed. Nevertheless, this meeting will stand as an enduring tribute to Professor Snoeys who, during his lifetime, accomplished so much in developing the modal analysis tools and promoting its use to improve the dynamic behavior of mechanical structures.

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2/9/89

PHYSICAL ELECTRONICS

Solid State Electronics at CNR, Italy

by J. F. Blackburn. Dr. Blackburn is the London representative of the Commerce Department for Industrial Assessment in Computer Science and Telecommunications.

Introduction

The Institute of Solid State Electronics of Consiglio Nazionale delle Ricerche (CNR) was established in Rome, and began its work in 1970. It has concentrated on the development of devices based on advanced research and technology. One objective has been to establish working relations with the science community and with industry.

The Institute of Solid State Electronics deals with the close interaction between rapidly developing science and the growing market, with continuous exchange of information in both directions.

The main areas of activity of the Institute are: magneto-optics, structured analysis of materials, chemical sensors, microwave materials and devices, biomagnetism, electron beam and x-ray lithography, superconducting devices, and high-temperature superconductivity. Each of these fields is briefly described in the following paragraphs.

Magneto-Optics

Among the optical properties of magnetized materials, the most magneto-optical effects relevant to the Institute's work are the rotations, named for Faraday and Kerr, undergone by the polarization plane of a light beam traversing, or reflected by, a longitudinally magnetized sample.

Study of magneto-optical effects enables the fabrication of a number of devices which exploit such effects. These devices are used in displays and printers, and as active elements for integrated optics, reading heads for magnetic recording, and magnetic field measuring systems. In most cases, the base material of such devices belongs to the family of magnetic garnets, employed both as bulk crystals and as epitaxial films. It is possible to vary a number of the physical properties of garnets, to a large extent and in a controlled way, by changing their composition or subjecting them to appropriate post-growth thermal treatments.

For more than 15 years, the Institute of Solid State electronics has been active in the field of magneto-optics. Its scientists have studied garnets of several compositions using a technique called Angular Variation of Induced Anisotropy (AVIA). The technique is very effective in unambiguously identifying the crystal sites occupied by the magneto-optically active ions.

The Institute has invented and patented a new kind of magneto-optical display. It is now involved in a multiyear program dealing with the realization of bulk and epitaxial materials to be used as magneto-optical isolators and deflectors in some devices. The Institute cooperates with the University of Hamburg, West Germany, for the realization of Mossbauer Monochromators, garnet films enriched with the isotope Fe^{57}, able to extract radiation from the syncrotron light. This will make an x-ray source extremely monochromatic and collimated, and of great interest for studies in physics, material science, chemistry, and biology.

Structural Analysis of Materials

An accurate structural analysis of thin films and interfaces is required for the complete understanding of the phenomena they demonstrate and for the realization of more effective devices. Several techniques have been set up for thin films studies, mainly based on x-ray diffraction and Mossbauer spectroscopy. The activity has mainly been directed toward the study of epitaxial films of garnets, III-V heterostructures, x-ray standing waves, synchrotron radiation, and Mossbauer spectroscopy.

When a garnet film is subjected to ion implantation or to thermal treatment in reduced atmospheric pressure, a thin layer is formed on top of the film with structural and magnetic properties modified with respect to the underlying film. A characterization of these thin film layers was carried out by means of double-crystal x-ray diffraction and conversion electron Mossbauer spectroscopy. The possibility of replacing the ion implantation by simpler thermal treatment to obtain thin layers with a different orientation of magnetization is the subject matter of an approved patent.

In collaboration with the Department of Electrical Engineering of the University of Colorado, Boulder, III-V heterostructures grown by metallic oxide controlled vapor deposition (MOCVD) have been studied. Structural characterization of $Ga_xAl_{1-x}As$, GaAs:Se, and GaAs:Zn has been carried out.

The technique of x-ray standing waves is a recent method for very accurate studies of surfaces and interfaces. Work on thin layers of gadolinium-gallium-garnet crystal has been carried out at the AT&T Bell Laboratories. The apparatus for carrying out this technique with high resolution and reliability is now in operation at the Institute. A project for the studies of adsorbates on crystalline surfaces is underway.

An experimental station with high angular resolution for x-ray standing waves and for Mossbauer spectroscopy with synchrotron radiation is being put into operation at the Wiggler line of Adone in Frascati. The activity of epitaxial layers characterization is very important in connection with advanced growing techniques such as molecular beam epitaxy (MBE) and MOCVD. The institute is collaborating with Centro Studi e Laboratori Telecommunicazioni (CSELT) on this subject.

Mossbauer spectroscopy in the transmission geometry has been applied to the investigation of the magnetic phase of garnets and to the problem of the distribution of some ions among the different sites of the garnet structure. Futhermore, Mossbauer spectroscopy has been applied to the investigation of the phase transformation austenite-martensite in some steels of technological interest.

Chemical Sensors

The activity at the Institute on sensors has dealt with basic devices which can allow the detection and quantitative analysis of gases including H_2, O_2, NH_3 and ions in solutions. The systems considered as testing vehicles for the fabrication of chemical sensors are:

- MOS, MIS (metal oxide semiconductors, metal insulator semiconductors) structures
- Surface Acoustic Waves (SAW) structures
- Pyroelectric (Py) structures

MIS and MOS structures, using either silicon or amorphous silicon semiconductor material, are charge-responding devices which use a catalytic metal as gate electrode. When Pd is used the MOS is sensitive to H_2 and shows a reversible response in the presence of O_2; I/V and C/V measurements are usually employed for the analysis of the responses. SAW structures are mass responding devices. They have been designed and fabricated at the Acoustic Institute of CNR and successfully tested at the Institute of Solid State Electronics. By using Pd or Pt on the acoustic path of the devices, it is possible to get a remarkable sensitivity to H_2 and NH_3 respectively.

Pyroelectric devices are sensitive to temperature variations occurring during a given catalytic reaction. A calibration of these devices has led to the determination of their thermal sensitivity of about 0.24×10^{-12}/k cal/cm^2/sec. Research on noise has also been active over the last 3 years to give a complete characterization of the above devices in operating conditions. Another important initiative was the production of thin films of A-Si, A-Si:H and new insulators. The Institute is cooperating with a private research institution in the fabrication of chemical-sensor-oriented devices.

Microwave Materials and Devices

Progressive refinement of the Liquid Phase Epitaxy (LPE) technique over the last decade has allowed the reproducible growth of magnetic garnet films having a great variety of compositions. In particular, single crystal yttrium iron garnet ($Y_3Fe_5O_{12}$, shortly YIG) epilayers characterized by low magnetic losses at microwave frequencies (commonly in the range 1-20 GHz), have become available to develop planar devices based on the propagation of magnetostatic waves (MSW). MSW integrated devices and subsystems can play a significant role in such applications as dispersive and nondispersive delay lines, tunable filters and oscillators, pulse compressors, signal limiters and enhancers, convolvers, and correlators.

The technologies available in the Institute have allowed the fabrication of prototypes of:

- A dispersive delay line (DDL) usable in the range 4-12 GHz, with average delay time of the order of 150-200 ns, -3 dB bandwidth of 400-500 MHz, insertion loss of about 12-15 dB
- A nondispersive delay line obtained by cascading two DDL's through the frequency inversion of one of them (original patented technique) with the above characteristics
- An oscillator tunable in the C and X band with high spectral purity comparable with or better than that of commercial YIG spheres oscillators (typically -100 dBc/Hz at 10 kHz offset)
- A tunable narrow band filter obtained by using multilayered films alternating propagating (YIG) and absorbing (Ca-doped YIG) layers.

The basic research on novel garnet compositions and propagation processes is active and is the source of interesting results, such as microwave solitons, which offer promise for further developments in applications.

The above activity has been performed in cooperation with Selenia S.p.A., an Italian company, in the field of radar and telecommunications. Selenia is the main user of the know-how and devices. The Institute also cooperates with several American universities and institutions, mainly in magnetic, propagation, and electric properties of garnet films.

Biomagnetism

Biomagnetism is the study of magnetic signals associated with biological activity of functional areas of the human body. The detected signals are generated by intracellular bioelectric currents. As the magnetic sensor is essentially an inductive coil positioned outside the body, the technique provides a unique totally non-invasive means for directly investigating the biological activity. These signals are very weak and they always appear mixed with the environmental noise, which is several orders of magnitude stronger. Only the development of quantum interference devices (SQUID's) provided a magnetic sensor featuring a sensitivity adequate to the task. Various procedures have been proposed to reduce the ambient noise such as the use of heavily shielded electromagnetic rooms and the rejection of fields originating relatively far from the magnetic sensor obtained by means of a particular geometry for the detection coil, which provides the spatial discrimination.

In Italy, activity in biomagnetism began 10 years ago at the Institute of Solid State Electronics. It has operated a four-channel system for the last several years, and this work has enabled detection of magnetic fields simultaneously at four sites with sensitivities spanning around 40 ft/ $\sqrt{\text{Hz}}$. Their recent studies have concentrated on the brain. The magnetoencephalographic (MEG) study of spontaneous brain activity is carried out in collaboration with the Neurosurgery Institute of the University of Rome. A systematic investigation performed first on a normal subject, and later on pathological ones, has demonstrated that significant new information can be inferred from the magnetic analysis of cerebral activity. Through a systematic investigation of patients affected by various kinds of focal epilepsy it has been demonstrated that the magnetic approach is powerful in the localization of the cortical areas responsible for the pathological activity. The Institute's activity in this work over the last several years has been carried out in collaboration with the neurophysiological groups of the University of Rome. The main goal is to systematically compare the spatial distribution of the electric potentials and magnetic fields over the scalp of normal subjects and to identify common aspects and features which characterize only the magnetic approach. At present, a collaboration between the Institute and Elettronica S.p.A. is underway to develop a nine-channel system for neuromagnetic research. Finally, in cooperation with the CNR project on Superconductivity and Cryogenics a "Class 100" system will be developed between 1988 and 1991.

Electron Beam and X-ray Lithography

The Institute has been active in micron and submicron lithography since 1985. The main systems available are an electron beam microfabricator (Cambridge EBMF6) and deposition machines, including thermal evaporators and dc and rf magnetron sputtering for the production of thin layers of insulators, metals, and amorphous semiconductors. A clean room is also available for the processing of prototype devices.

The main research themes in the Institute's Electron Beam and X-ray Lithography center are:

- Application of the lift-off technique in the micron and submicron regions

- Application of the electroplating desposition technique for x-ray mask fabrication
- Studies of scattering and backscattering problems in electron beam lithography
- Gate design and realization by the lift-off technique for GaAs MESFET and GaAs HEMT
- Micron and submicron sensors and cantilever structures for radiation-sensitive devices
- Optical and x-ray mask fabrication
- Device characterization.

The most important results (metallic patterns) obtained thus far by using both the EBMF and the lift-off techniques are:

- In the micron region – Al lines with line width of about 1 μm and thickness greater than 6000 angstroms
- In the submicron region – Au lines with line width of about 0.2 μm and thickness around 1000 angstroms
- Prototype of BN x-ray masks with fold-absorbing patterns (linewidth of about 0.2 μm and thickness greater than 8000 angstroms) have been achieved by EBMF and electroplating deposition.

The result are continuously transferred to the main electronic industry in Italy, SGS-Thomson (Milan) which is a partner with the Institute in the National Microelectronics Program and the CNR project "Materials and Devices for Solid State Electronics."

The Institute has recently begun a program in mask technology and resist processes for x-ray lithography applications in submicron technology. The program is part of an ESPIRIT project in which the Institute is prime contractor.

Superconducting Devices

The study of dc-Superconducting SQUID's enables investigation of devices with noise near the quantum limit. The best devices are obtained with Josephson junctions with high-quality barriers. Thus the study of various Josephson junctions is important in the research. Other devices studied are planar gradiometers and long Josephson junctions. The most important application of the SQUID's is in biomagnetism. Investigations are underway in planar gradiometers for the future integration on a multichannel system – i.e., dc-SQUID's and pick-up coil, in gradiometer shape, integrated on the same chip. Dc-SQUID's are also used in gravitational experiments carried out by the Rome group at CERN and in the future in the Gran Sasso underground laboratory. The Institute also plans to use dc-SQUID's in experiments for detection of neutrinos and ULF signals from satellites. The Institute is also developing a fabrication process based on either direct writing on a silicon wafer by an Electron Beam Micro-Fabricator (EBMF) or optical lithography using chromium masks generated by the EBMF. The thin-film technology is also used in order to pattern the various layers over the wafer. The process uses the lift-off technique on five out of the six layers (AuPd, NB_2O_5SiO, Niobium Oxide Barrier, and PbAnIn) while the first one (Nb) is obtained by reactive ion etching.

The institute has a complete testing facility to study noise and the main physical properties of dc-SQUID's and Josephson junctions at temperatures as low as 1 K. They have developed an on-line data acquisition system, and numerical simulation is used to study the dynamics of the devices.

There is an on-going collaboration with an Italian electronics manufacturer to produce a nine-channel magnetometer system for use in biomagnetism.

High-Temperature Superconducting

In early 1987, the Institute obtained single-phase-sintered pellets of the high-temperature superconductor $YBa_2Cu_3O_{7-x}$, which exhibited a transition temperature of 93 K with a transition width of about 1 K. Soon after that, the work began on the possibility of getting single crystals of the new material to perform measurements of the physical properties of the compound. In May 1987, the Institute obtained the first single crystals in Italy, which were characterized in the laboratory from the structural and the electric and magnetic viewpoints. The structural investigation was carried out using a θ--2θ x-ray diffractometer. The electrical resistivity was measured as a function of temperature using the four-lead method. The ac magnetic susceptibility as a function of temperature was measured using a SQUID device of the change of inductance of a pickup coil upon the occurrence of the superconducting transition. This is particularly useful in determining the transition temperature when the sample is too small to perform electrical resistivity measurements. Single crystals of $YBa_2Cu_3O_{7-x}$ about 4 mm wide have been obtained, with a transition temperature of about 85 K. Some effort has been devoted to finding the most appropriate eutectic of Ba and Cu in the flux method used to promote single-crystal growth. The fabrication of thin films of the new compound has begun. The facilities and the competence in the laboratory will be used to fabricate thin films and devices such as SQUID's.

In this work, collaboration with industry is very promising.

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3/23/89

PHYSICS

International Conference on the Applications of High Magnetic Fields in Semiconductor Physics

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The International Conference on the Application of High Magnetic Fields in Semiconductor Physics held in Würzburg, West Germany, from 22 through 26 August 1988, focused as its main theme on magneto-optics and magneto-transport in quasi-two-dimensional electronic systems. The format of the meeting followed the tradition established at Würzburg for earlier conferences in this series. The formal presentations included only invited papers with ample time left for discussion. The remainder of the contributions were included in poster sessions which permitted direct one-on-one interaction among the 230 participants at the conference.

Low-Dimensional Magnetotransport

About one-third of the 45 invited papers and 80 poster presentations were concerned with the quantum Hall effect (QHE). The integral QHE, discovered a decade ago, and the fractional QHE continue as active topics for research in semiconductor physics. The QHE is characterized by the appearance of plateaus in the Hall resistance when the filling factor for the Landau levels has exact integral values or, at very low temperatures, fractional values with rational indices. Coverage of the Quantum Hall Effect at this conference is provided in the accompanying report by John Furneaux of the Naval Research Laboratory. The present report will give some introductory remarks on the QHE but will focus mainly on other aspects of low-dimensional systems as well as on magneto-optical and magnetotransport studies of 3-D semiconductors.

There now appears to be consensus among theorists that the phenomenology of the integral QHE is reasonably well understood in terms of one-electron models in which the Landau levels are broadened by disorder and the extended states available for conduction occupy only a few levels in the middle of each band. These models agree reasonably well with experiments but must be modified to include electron exchange and coulomb interactions to explain the field and temperature dependencies for the activation energies observed in transport experiments. Not all experimentalists are convinced that the theory is firmly based, and more work is needed to bring theory up to the current level of experiments for the integral QHE.

Studies of the fractional QHE continue to provide surprises, mainly from the experimental side. It is now rather generally accepted that the fractional QHE reflects the properties of a new type of incompressible quantum "fluid" of electrons constrained to 2-D motion. The emerging quantization rules for the elementary excitations of the 2-D fluid appear to have similarities in common with those for quarks and for solitons in conducting polymers; i.e., they have fractional charge and do not obey simple spin statistics. Early theories for the fractional QHE predicted that only odd denominators should occur for the fractional filling factors corresponding to steps in the Hall resistance. Recently, experiments in very-high-mobility layers at temperatures in the millikelvin regime have demonstrated the existence of plateaus in the Hall resistance for filling factors with even denominators (5/2, 7/2, etc.). Eisenstein of AT&T Bell Laboratories presented the results of some very-high-resolution experiments performed on GaAlAs heterostructures with temperatures extending down to 20 mK and fields up to 30 T. A well-developed plateau was observed for a filling factor of 5/2 for temperature below 100 mK. No structure was observed for filling factors of 1/2 and 3/2 which would correspond to half-filled Landau levels for each of the two spin states with orbital quantum number $n = 0$. Eisenstein explains these results in terms of a difference in electron correlation in the first and second Landau levels and suggests that the ground state for a filling factor of 5/2 is not spin polarized.

Apart from the QHE, another one-third of the papers at the conference were concerned with other aspects of low-dimensional electronic systems, as constrained by quantum wells, heterolattices, or lateral 1-D and 0-D device electrodes.

Quantum Well Effects

Magnetic fields have an important role in studies of the effects of dimensionality on electronic systems. Classi-

cally, magnetic fields alter the direction of electronic motion without acceleration; i.e., the carrier is confined to a circular cyclotron orbit without changing the kinetic energy of the carrier. The influence of the magnetic field on dimensional effects can be characterized quantum mechanically, in terms of a length scale associated with the radius of cyclotron motion. This radius decreases inversely with magnetic field for degenerate carriers in high Landau levels (weak field) and inversely with the square root of fields for carriers in the quantum limit (strong field); i.e., all carriers in the lowest Landau level.

The cross-over occurs at several hundred tesla (megagauss regime) for metals but is in the range of tens of tesla for semiconductors with moderate free-carrier concentrations 10^{15}-10^{18}cm^{-3} the variability of the cyclotron radius with magnetic field in relation to other length scales in the system, such as the inelastic scattering length, the Bohr radius, the Fermi wavelength, channel spacing, etc., provides a way to "tune" the system through dimensional crossovers.

Lawrence Eaves of Nottingham University UK, in collaboration with French researchers (at Toulouse and Grenoble) reported on resonance tunneling experiments on double-barrier structures fabricated with n-type GA_XAS_{1-X} and GaAs epitaxial layers. The basic device configuration is a sandwich of an n-type GaAs emitter layer, an undoped GaAs quantum well, a second GA_XAl_{1-X} barrier, and a top-layer n-type GaAs collector. The tunneling characteristics of such structures depend primarily on the intermediate electronic states in the central quantum well. With magnetic field perpendicular to the plane, weak magneto-oscillations are observed at low bias voltages corresponding to the modulation of the Fermi level in the emitter as Landau levels pass through. This is nonresonant tunneling. At higher bias voltages, resonant tunneling sets in and a new series of magneto-oscillations is observed. With magnetic fields parallel to the plane, there are two series of oscillations for wide quantum-well structures. At low fields the oscillations corresponds to tunneling via traversing orbits which span the quantum well and are reflected at both edges. At higher fields, a second set of oscillations are observed corresponding to "skipping" orbits which are confined to reflections from the emitter plane only. Other features observed in the wide-barrier tunneling devices include phonon-assisted tunneling and bistability, with asymmetric barriers.

Fred Koch of the Technical University of Munich (TUM at Garching) reported on a series of investigations at TUM to determine the critical layer concentrations and layer spreading for δ-dopant layers in epitaxial GaAs and Ga_XAl_{1-X}. δ-doping is a term used to describe a single atomic layer of active dopant atoms in a semiconductor crystal. This is distinguished from sheet-doping in which the dopant atoms are uniformly distributed over a macroscopic volume. The δ-doped crystals are prepared by interrupting the epitaxial growth of a host crystal (GaAs) to inject dopant atoms on the surface (Si) followed by a resumption of growth for the host crystal. At surface concentrations above 10^{12}cm^{-2}, the δ-layers exhibit "metallic" conduction and electronic sub-bands characteristic of 2-D systems. Koch and his group at TUM have carried out a series of investigations to determine critical concentrations for dopants and the extent of δ-dopant spreading lateral to the doping plane. The experiments relied on measurement of the Schubnikov-de Haas effect to measure free-carrier concentrations and sub-band occupations. Pressure-tuned D_X levels were used as a "caliper" for the energy of occupied states above the Γ-point energy band minimum.

Koch and colleagues were able to show that ion spreading within the width of the ground state wavefunction does not change energy levels appreciably but can lead to different values of the sheet resistance for the same carrier concentrations. Studies of a series of samples prepared by K. Ploog at the Max Planck Institute for Solid State Research in Stuttgart show that the incorporation of Si impurities up to a bulk saturation value of 10^{19}cm^{-3} will lead to δ-layers, as described above, when the sheet densities is less than $3x10^{19}$cm^{-3}. For measured sheet densities above this value, ion spreading is broader than the ground state wave function and thus is more properly described as sheet-doping.

Laterally Constrained 2-D Magneto-Transport

Several papers at the conference dealt with transport in 2-D electronic systems with lateral constraints. David Ferry of Arizona State University reported on studies of lateral surface superlattices used as gate electrodes on MODFET or MESFET device structures. With submicron meshes it is possible to generate quantum "boxes" on a scale small compared to the inelastic mean-free-path, Fermi wavelength, etc. The linear and nonlinear coupling between such 0-D quantum boxes arranged in periodic arrays could have important implications for new devices. The experiments, still at a preliminary stage, exhibited several interesting and unusual effects in the variation of the magneto-conductance as a function of magnetic field. These include incipient universal conductance fluctuations and Aharonov-Bohm oscillations. The data appear very similar to noise spectra; however, the fluctuations in the conductance as a function of magnetic field are reproducible.

Alan Fowler of the IBM Thomas J. Watson Laboratories reported on studies of the magneto-conductance of very-small-scale, single-device structures with submicron channels. He also observes noise like fluctuations as a

function of magnetic field. The conductance fluctuations are reproducible as a function of magnetic field at a given temperature but are uncorrelated for different temperatures. Fowler ascribes this behavior to the fact that, for the dimensions involved, only a small number of impurity levels lie within kT of the Fermi level. Also, he postulates that the conductance is dominated by the path of minimum resistance for tunneling between adjacent impurity sites. This model can explain the lack of correlation for different temperatures in that different impurity sites are active at different temperatures and at different values for magnetic field. It also can explain the appearance of Aharonov-Bohm oscillations by the differences in enclosed flux for the alternate current paths.

Research in Megagauss Fields

Noboru Miura of the Institute of Solid State Physics (ISSP) in Tokyo reviewed recent experiments in pulsed magnets with magnetic fields extending into the megagauss regime (100 T). He reported on measurements of the upper critical field for $YBa_2Cu_3O_{7-x}$ superconducting oxides which have superconducting transition temperature to above 90 K. Two measurement techniques were used: the first detected the disappearance of superconductivity by monitoring the hysteresis in the magnetization curve of sintered samples at peak field (reversal of dB/dt); the second monitored the transmissions of 22-MHz radiation through a sample disk as a function of temperature and magnetic field. The results indicate that superconductivity persists to fields above 100 T for $B \| c$ and above 50 T for $B \perp c$.

Other recent experiments carried out at the ISSP included cyclotron resonance in $Pb_{1-x}Ge_xTe$ in dilute magnetic semiconductor compounds. The experiments on the lead-germanium-telluride compound semiconductors determined the field and temperature dependencies for the field-induced ferroelectric phase transitions which occur in mixed crystals in this series. A transition temperature of 42 K was observed at 42 T and 48 K at 91 T for x = 1 percent. Measurements of the magnetization in dilute magnetic semiconductors (DMS) of the type $Cd_{1-x}Mn_xTe$ were carried to fields above 100 T using Faraday rotation to monitor the magnetization.

Miura said that the pulsed-field experiments at 100 T are more difficult to execute and are not as precise as experiments carried out in dc fields. However, the megagauss facility at ISSP remains as the only laboratory worldwide that is accessible for solid-state experiments in fields above 100 T.

Magnetic freezeout and Wigner Crystallization high field measurements of the Hall coefficient in narrow-gap semiconductors such as PbTe and $Hg_xCd_{1-x}Te$ exhibit departures from the strict constancy expected for free carriers in the high-field limit. The origins of these departures are a matter of some controversy with alternate explanations proposed in terms of Wigner crystallization or magnetic freezeout. Wigner crystallization has been predicted theoretically as the ground state for a free electron gas at 0 K. In this state, the electrons (or holes) arrange themselves in a crystalline array under the influence of the Coulomb repulsion. There is good evidence for Wigner crystallization in 2-D electron systems. The situation remains ambiguous for 3-D. Magnetic freezeout results from the shrinkage of wave functions for localized states in large magnetic fields. Freezeout has been observed in other narrow gap semiconductors, such as InSb, but not in lead salts and only very recently in narrow-gap $Hg_xCd_{1-x}Te$ and related zero-gap semiconductors.

Gunther Bauer of Montann University, Austria, in collaboration with others at Brown University and the National Magnet Laboratory, has carried out a very thorough series of experiments to measure the magneto-transport coefficients in PbTe in fields to 20 T and temperatures to 0.4 K. The PbTe is an attractive candidate for such studies since magnetic freeze-out is expected to be very weak due to its extremely large dielectric constant and small effective mass. The anomalous field and temperature dependencies observed by other groups in $Hg_xCd_{1-x}Te$ were evident in these experiments to approximately the same degree for materials with similar energy gaps. The temperatures, however, were considered to be a factor 10 too large for Wigner crystallization. Transitions involving a Peierl's instability or one-dimension change-density-wave also appear to be ruled out. Bauer does not have an explanation for the anomalous behavior but suggests disorder and correlation effects may have important roles.

Dilute Magnetic Semiconductors

Several laboratories reported on recent work on dilute magnetic semiconductors (DMS) which are a relatively new class of electronic materials that combine active magnetism with traditional semiconductor properties. They result from the partial substitution of transition metals for the normal cation in II-VI compounds such as CdTe, ZnTe, HgTe, etc. The first systems to be investigated in detail were the wide-gap chalcogenides of group II metals with manganese as the active magnetic element. Such semiconductors have unusual spin splittings and magneto-optical properties due to the large exchange interaction between the d-electrons of the transition metal and the host-crystal electrons which acts in combination with the antiferromagnetic coupling between the magnetic ions themselves. A. K. Ramdas of Purdue University reviewed his optical studies on the cadmium and zinc chalcogenides with manganese as the active magnetic

ingredient. At low temperatures the magnetic field dependencies of the exciton Zeeman splittings, the Faraday rotation, and the Raman spin-flip excitation of electrons bound to a Ga donors are extremely large compared to the corresponding effects for manganese-free host crystals. The amplification of the spin-dependent energies is explained by the large exchange coupling between local magnetic levels and extended band states. Alternatively, the magnitude of the splittings can be attributed to internal exchange fields on the order of 10's of tesla.

Peter Wolff of the Francis Bitter National Magnet Laboratory reviewed work done at FBNML in collaboration with other groups at Brown University and Warsaw, Poland. Research on DMS has been the focus of semiconductor research at FBNML over the past 5 years. The topics for investigation included studies of: the bound magnetic polariton, magnetization steps and enhanced manganese-manganese interactions; metal-insulator transitions, and ordered DMS crystals. A strong theme in the FBNML program is the development of a basic understanding of the physics of the unusual magnetic properties with the view of tailored materials for device applications at non-cryogenic temperatures.

Michael von Ortenburg of Wurzburg University, West Germany reported on a very interesting series of experiments on Fe-doped HgSe and $Hg_{1-x}Mn_xSe$ crystals carried out in fields extending into the megagauss regime. Iron doping of DMS crystals introduces a quasi-localized Fe^{2+} or Fe^{3+} resonant level in the conduction band. For Fe^{2+} concentrations exceeding $5 \times 10^{18} cm^{-3}$, the Fermi level is pinned to the Fe2+ state and electrons can shift iso-energetically between localized and delocalized states. This results in a 3-D analogue of the quantum Hall effect by introducing "steps" in the Hall resistance as Landau levels are swept through the localized Fe^{2+} dopant, and also dramatically improves the mobility of the free – carriers with consequent reduction of the Dingle temperature and other manifestations of scattering.

Outlook for High-Field Research and Facilities

Interest in high magnetic field research in Europe appears to be very strong with widespread support for developing improved facilities. Semiconductor research in high magnetic fields is now strong in Germany and appears to be on the increase. Major centers for semiconductor research in high magnetic fields are located at the Technical University in Munich, at the Max Planck Institute in Stuttgart, and at the University of Hamburg. Laboratories in the U.K. at the University of Oxford and Cambridge and at Imperial continue the tradition of very-high-quality programs on semiconductor research involving high magnetic fields, but the size of the efforts are modest compared with the major continental groups. The University of Nottingham has developed a strong semiconductor program with several key investigators in the Physics and Electrical Engineering Departments.

The major laboratory for high magnetic field research in Western Europe is the center at Grenoble, which is jointly supported by the CNRS and The Max Planck Institute for Solid-State Research in Stuttgart. The Grenoble facility has received approval to up-grade dc magnets by acquisition of a 20-MW power supply and has approval to build dc magnets for operation at 40 T. Other major high-field laboratories in Western Europe include the dc magnet laboratory at Nijmegen (the Netherlands) which has dc fields to 30 T; the quasi-static pulsed field laboratory at the University of Amsterdam with fields to 45 T; and, the pulsed field laboratory at France's University of Toulouse with fields to 45 T. Both pulsed field laboratories have major initiatives, approved which will increase peak fields to 60 T or above for pulse times on the order of a second. The US has no comparable initiatives, and its past leadership in high-magnetic-field research and facilities is fast being overtaken by research initiatives in Western Europe and Japan.

3/22/89

SUPERCONDUCTIVITY

Superconductivity Research in Italy

by Alan F. Clark. Dr. Clark was the Liaison Scientist for Superconducting Materials and Electromagnetics in Europe and the Middle East for the Office of Naval Research European Office. He completed his tour at ONREUR and is now at the National Institute of Standards and Technology in Washington, DC.

Professor Rizzuto, University of Genoa, is the chairman of the Italian committee charged with directing all the superconductivity research in Italy, including the new high temperature superconductors. Organization of the new high Tc Superconductor research in Italy is also directed by him. This coordination and funding is taking place on three levels. He is coordinating the research measurements on an informal basis between 33 different groups at 20 different universities doing basic research on measurements on the new high temperature superconductors. This is being done to avoid duplication of measurement and facilitate the arrangements of exchanging samples and specimens for complete and accurate characterization. The second level of coordination is necessary because the Italian government's fundamental research funds in Italy are providing 2 billion lire (about $1.5 million) to fund high temperature superconductor research at various existing laboratories and universities. Key players in this field are government research laboratories in Rome and Naples, the Universities of Genoa, Milan, and Torino, and various other universities scattered around the country. Some of the money is already going into industrial laboratories, particularly those which have had some experience in ceramics. The third level of coordination is taking place because of a new program funded at the level of 10 billion lire (about $8 million), which is for conventional superconductivity research. This program began in 1988, but was based on a program that was initially developed by Rizzuto starting in 1982 and then finally agreed upon for funding in about 1985. It has taken this long to get the funds flowing. A five-component program, it is aimed strictly at conventional superconductors. The five components are:

1. To build a MHD magnet for very-high-power levels, ostensibly to be provided to the Soviet Union for trial in the MHD system.

2. To build as high a magnetic field level as possible with a fairly large bore. This is probably Nb_3Sn at 15 to 18 T, perhaps with pumped liquid helium. The target is 18 T pumped but they may have to modify that to achieve the 18 T. The objective is a fairly thin solenoid with a very large bore with the idea of using a Bitter insert to build Italy's first high-field system capable of approaching 25 T.

3. The development of conventional superconducting materials, principally multifilamentary NbTi and Nb_3Sn.

4. The fourth component is for biomedical electronic applications based at a research laboratory in Rome for multi-SQUID detectors of both heart and brain waves. This is being driven by the fact that there is a private company in Rome which is trying to develop this as a product for marketing throughout Europe.

5. The last component is superconducting electronic applications using detectors, SQUID's and sensors, and all the conventional circuits in superconducting electronics.

A generalized conclusion about the high Tc superconducting research in Italy is that there are quite a few active groups working in a variety of measurement techniques in everything from electron spin resonance at the University of Parma (which is done in conjunction with IBM Zurich) to fairly extensive critical current measurements at the University at Genoa. There are several groups attempting to grow single crystals either through sol-gel techniques or epitaxial growth on substrates or with Italy's first MBE machine applied to this problem. They have been successful through various chemistry groups in substituting basically all the rare earth elements for yttrium in YBCO. They have had virtually no success with substitution with any of the transition elements or with fluorine or sulfur for the oxygens.

Rizzuto is also consulting for Fiat, IBM Italy, and Ansaldo. The interest from Fiat is for their sensor and other superconductor electronic applications, microwave power applications for radar, and just to be generally on top of the development of this new technology. Consultation for Ansaldo is to help them develop a program for ultimately marketing the new high temperature superconductors. Ansaldo is probably one of Europe's largest manufacturers of superconducting magnets and other cryogenic systems, having at least 50 percent of the mag-

netic development work for the HERA high-energy program and various other CERN-related systems.

Ansaldo Componente, Genoa

Ansaldo is an older electrical motor and generator manufacturing company which has branched out into the manufacture of electromagnets for a wide variety of applications, many of these being superconducting magnets. They have a long history, going back to 1974, building large superconducting magnets principally for use in high-energy physics. Their specialty appears to be very large magnets requiring equivalently big structures. These large structures frequently entail the application of exceedingly high compacting stresses in manufacture or the welding of very large cases – and frequently the epoxy impregnation and curing of very large structures. They have extensive experience in the potting of very large structures with epoxies. They have manufactured everything from very large, thin detector solenoids for high energy physics to a trial magnetic resonance imaging system (which is presently with the biomedical electronics company).

Ansaldo's heir present major project is building the dipole magnets for the HERA accelerators. They have 10 of these and are in the process of testing them before continuing to build another 232. These magnets are 9-m-long dipoles with an interior core of about 6 cm. The technicians use a surprisingly small amount of instrumentation and test the magnets only by running to the quench current. Even then they only quench one out of ten except that in the first batch of ten all are run to quench current. So far Ansaldo has made only NbTi superconducting magnets and one internally cooled Nb3Sn conductor. Their biggest effort before the HERA magnets were about 20 superconducting coils for the toriodal field ring. Those were 9-tesla magnets with 2.3-m diameter. They are also presently making several solenoids for various superconducting test facilities around Italy, apparently in connection with the conventional superconducting program described above. Ansaldo puts in about 2 billion lire per year strictly on the development of new ideas and research. The rest of the research is performed on contract principally with the high-energy physics groups around Europe. For this they also manufacture very many dipole and quadrupole and solenoid magnets of normal conductors – copper or aluminum water- and occasionally nitrogen-cooled.

Dr. Franco Viraldi, research director, frequently referred to the sudden expansion in superconducting magnet production for Ansaldo. I saw quite a few signs of new offices and extensive new equipment, frequently of the large structure type. Apparently, they are trying to focus on the construction of very large systems. There was significant interest in measurement problems related to large conductor critical currents, such as self-field effects and ripple effects due to noisy power supplies. This indicates some real problems between the conductors as measured by the manufacturers and as performing in large magnet structures. It also indicates that the magnet designer is trying to operate closer and closer to the critical current along the magnet operating load line.

University of Genoa – Physics Department

The work at the University of Genoa on the new high-temperature superconductors consists principally of parameter measurements. A four-terminal, pressure contacts system measures resistance versus temperature. This is used to monitor the manufacture of the new YBCO by the nearby Institute of Chemical Physics. The university's Physics Department has tried a whole variety of chemical combinations including most of the rare earths, but they have found that their best success has been with barium peroxide instead of barium carbonate. This provides extra oxygens and makes the final oxygen anneal unnecessary. The physical properties resulting from this are not significantly different. The other primary measurement technique is to determine the critical current by measuring the field difference inside and outside a small ring. The small ring is created by drilling a hole inside of one of the compacted disks of the new superconductor. These investigators have found difficulty in this measurement, however, because the measurements at very low field and relatively high fields, over a few hundred gauss, sample different parts of the superconductor. Looking at only the low fields they see the bulk critical current values going across the weak links between the grains. As soon as 10 to a 100 gauss is reached this is eliminated, and then just the critical current within each grain is observed. Frequently these are opposite signs so they can generate any kind of hysteresis possible by extending to different field levels before reversing. These researchers will try to eliminate this by placing the internal Hall probe at a location inside the tube where the contribution of all the individual grain circulating currents is zero. They will also try and make a solenoid of the new superconductor where each grain is insulated for the other by a mixture of finely divided powder in epoxy. This should permit them to separate out the component of magnetization due strictly to the individual grains with none of the links being connected.

Other conventional superconducting work going on in the department includes two principal efforts: The determination of large conductor critical current of the HERA conductor. This is done in a 6-T, 50-cm-bore solenoid. They put six to eight one-turn samples inside and run a series current through them all of about 7000 A. This creates a rather large force which is constrained by a clamping mechanism holding the conductors in a flat disk of

fiberglass epoxy. This becomes a 1-m-long sample where the voltage taps are about 80 cm apart, and they make no special effort to localize the voltage taps, but current contacts are extended over about 10 cm of copper. They also will be determining the "n" value as well, and have so far found a good flat zero-voltage current base. The other conventional superconducting effort is in the quantum Hall effect where they have just obtained a small 16-T solenoid from Oxford Instruments and also a dilution refrigerator to use with it. Their principle objective is to reduce the noise on the voltage steps, and they are working with an institution in Turin whose responsibility is standards. This collaboration also existed for the standard volt which was concluded a while back.

In the low-temperature laboratory the department also is making a significant effort in the determination of specific heat of three principal categories of materials: the heavy Fermion superconductors, the A15 superconductors, and valence intermetallics. The objective here is using a 8-T magnetic field to depress the critical current so they can track the specific heat gamma to much lower temperatures.

One other effort in superconductivity involves the manufacture of RF cavities out of very large pieces of niobium for high-frequency applications for electron accelerators. There is also some development of using A15 films inside copper blocks for these RF cavities as well. The department's principal contribution to this point has been in designing a cavity shape such that the skipping electrons do not impact the surface with enough energy to cause a local reversion to the normal state.

The other major effort in the Department of Physics falls mostly in the surface sciences where the objective is study of catalysis and other fundamental surface phenomena. Two experiments of interest here were electron energy loss, or EELS, to study chemisorption and catalysis, and ballistic phonon studies in single-crystal silicon. Altering the reflecting surface allows study of various surface phenomena. For example, liquid helium on the reflecting surface measures the Kapitza resistance, or a superconductor yields some measure of the interaction of the phonons with the flux line lattice as a function of field and temperature. The potential of this experiment is just beginning to be understood.

The development of superconductivity in Italy appears to be focused at the University of Genoa and Ansaldo, with many centers of excellence scattered around Italy. The large manufacturing capability here can be coupled with the basic understanding of the new high T_c materials as it is developed. The only gap that appears in this connection between university fundamental information and the development of products would be a good wire manufacturer or perhaps a good ceramics company. One of the apparent barriers to quick development of the new materials has been the slowness of the flow of information from the rest of Europe and the US. It is apparent that it takes a while for journals and other normal information channels to filter into the system here, which is why the effort of personal contact is a help.

Institute of Advanced Materials in Parma (also Physics Department of the University of Parma)

The Institute of Advanced Materials (MASPEC) consists of about 45 people funded by the Italian government and filling two functions: (1) the magnetic measurements of hard or permanent magnetic materials and also studying of recording materials, and (2) study of III-V compound semiconductors made by epitaxy, MBE, or drawing crystals from the melt. The balance is about one-third of the employees in the magnetic measurements and two-thirds in the semiconductor measurements. The magnetic measurement group is headed by Professor G. Asti, who is now transferred over to the university. MASPEC claims to be the best group in Italy for magnetic materials and magnetic measurement.

For facilities they have several small magnets (about 3- or 4-T, copper, water cooled), a vibrating sample magnetometer, and a pulse field capability to 30 T which is liquid nitrogen cooled. They have just acquired several pieces of new equipment, a 12-T superconducting magnet from Oxford Instruments along with the dilution refrigerator, and also some HP waveform recorders capable of 10μs per point with 10-bit resolution for digitized data taking. This latter instrument will be used principally to record measurements from the pulsed field, because the pulse is on the order of 0.8 ms long with a sinusoidal shape running to 30-T. With the new instruments they will extend their capabilities from 0.3 K to room temperature and above. They will use this primarily to study magnetic materials, the quantum Hall effect, and the upper critical field in new superconductors.

The magnetic measurement laboratory is headed by Dr. Fullvio Bolzoni, whose studies in the past have been principally on hard or permanent magnetic materials – the rare earth kind, with NdBFe the principal one. The objective is to make stronger and more highly anisotropic permanent magnets by substituting for cobalt in the rare earth compounds because cobalt is expensive. At present all of the work is government funded; there is not much industrial interest. They also work on manganese-aluminum with carbon substitutions to, again, try to enhance the magnetic anisotropy. Laboratory personnel also do some studies on the ferrites, particularly the barium ferrites, trying to reduce the coercivity by indium or copper substitutions without reducing the magnetization.

Study of the new high temperature superconductors is headed by Dr. F. Licci, and consists principally of two

parts: preparation and manufacture of the new superconducting materials using some of their old ceramic and single-crystal capabilities is headed by Dr. Licci. Magnetic measurements of magnetization critical temperature, critical field, and an isotropy field is headed by Dr. Bolzoni. A visiting professor, H.J. Scheel, who originally worked at IBM Zurich under Müller, is now a consultant at the MASPEC Institute. His specialty has been crystal growth, especially on strontium titanate. His group has been successful in growing single crystals of 7 to 8 mm, on the order of 1 mm thick, and able to separate them from the flux.

The Physics Department at the University of Parma has several superconducting efforts under Professor Fiesci. One is a theoretical study trying to relate the normal state resistivity to the superconductivity through such phenomena as thermal fluctuations. Two other groups, one headed by Dr. Bucci, have done muon annihilation studies and also some NMR and ESR studies – the ESR studies on the copper ions. A third group, headed by a Dr. Fontana, has done some Raman and micro-Raman studies to identify the phonon branches. He has established that there is a very strong anisotropy of the low-lying phonon branches, and by doing micro-Raman on different crystalities in a polycrystal has shown the existence of a very strong anisotropy in these low-lying modes. His group was also able to show (partly by theoretical calculation) that as the phonons traverse the single crystals in passing a twin boundary, the switching of the A and B axes can cause very strong electron coupling.

The Institute for Electronics and Solid State Physics (IESS), Rome

Dr. Paolo di Gasparis is director (replacing Dr. Paoletti) of this small research laboratory for CNR which has about 45 people – 12 or 13 Ph.D's and the rest support staff. Their funded salaries come from CNR, but of the rest of their budget only about 50 percent comes from CNR; that rest is obtained from the group of 10 or so "finalized research projects," of which the new superconductivity project is one. Another finalized research project in that category is materials and devices for solid-state electronics which also provides support. The institute consists of several groups all which are fairly closely coupled with the University of Rome and with an adjacent private industry, Silenia, which is doing an electronics research development primarily for the military including systems and components for electronic countermeasures, radar, and related fields.

The four groups within IESS are a semiconductor group, which is about half of the organization: a superconductivity group, a diagnostic group, and a magnetic materials (for microwave applications) group. The semiconductor group has three components – VLSI, x-ray lithography, and an extensive clean room containing an e-beam with a resolution of about 0.1 micron. Activities in the semiconductor group include work on sensors – primarily chemical sensors – and devices based on conventional semiconductors. The superconductivity group has three efforts, one in the new high T_c materials, a superconductivity SQUID effort, and the third that is strictly devoted to magnetoencephelograms for biomedical studies. The diagnostic group does primarily x-ray studies for structures. The fourth group makes various garnet films for applications in magnetoptics.

In high T_c superconductivity the institute has the capability of growing single crystals and has in force several collaborations with other institutions in Italy along with some energy gap measurements being made at the University of Colorado, Boulder, some electron spin resonance work with Northeastern University in Boston, and several efforts in the University of Rome including work concerning the upper critical field. Their funding came from the rather quick collaborative actions organized by Professor Rizzuto.

The biomagnetism studies are quite interesting with four rf SQUID's wired to four gradiometers. They do this work in a wooden building especially constructed to be completely nonmagnetic, and use computer software to get a resolution on the order of millimeters. They are preposing work with other institutions in Italy to develop a 100-sensor array.

The University of Napoli and the Institute of Cybernetics of the CNR, Naples

Dr. Boroni directs some small efforts at the University of Napoli's Physics Department and is also the director of the Institute of Cybernetics (Institute) which consists of about 100 people. The institute's budget is derived mostly from the CNR but also some from the new "finalized research projects." Most of the superconductivity comes from the "finalized research projects" on solid state devices for electronics. The Institute has an excellent reputation outside Italy for its work on conventional superconducting circuits. The group doing this work consists of about three or four professionals backed up by about three or more technicians. The rest of the Institute works in a variety of fields including biomagnetism and information science.

Italian funding for superconductivity in the new high T_c superconductors is about $3 million per year for 2 years spread out over a variety of laboratories in Italy. The finalized research project on superconductivity is a 5-year program at about $40 million per year; it has five phases as identified before: an MHD magnet, high-field magnets, superconducting devices, biomagnetism, and device materials. The Institute's work on superconductivity focuses principally in fundamental physics studies and

studies for circuits with applications for detectors and microwave cavities. The work on the cavities is concerned with exploring new materials – particularly molybdenum-uranium, which should have a low surface resistance and a high transition temperature. The work for circuits for detectors is both as threshold discriminator, where the transition between the zero current and the metastable critical current state can take place in a matter of picoseconds and for energy gap analyzers by looking at the distribution of the critical current due to the breakup of individual Cooper pairs. For the high T_c materials they have ordered new systems which will have three magnetrons in which they will use copper-barium and yttrium barium as sources for targets in an oxygen atmosphere. The detector studies, conducted by R. Christiano, involve looking at the macroscopic tunneling noise as the temperature is lowered for the tunneling transition between the two critical current states. The institute is also doing this because the Josephson junction system is typical of many physical systems and can look at the balance between two metastable states. They are looking at the transition from thermal noise to the quantum noise and the level of critical current at which the switching takes places. Thermal noise would be intrinsic for the system, but the quantum tunneling noise level depends strongly on the Josephson junction parameters.

In the new superconducting materials, the researchers at the Institute have evaporated a variety of shapes on to the YBCO palettes using silicon oxide as an insulator and then some cadmium sulfide with indium overlays with various junction circuits. They then look at the SIN or SIS circuit elements with indium changing from normal to the superconducting state between 4.2 and 1.9 K. Their I-V curves show a lot of interesting structure at 9.3 and 16.4 mv below this.

Conclusion

The response to the advent of the new superconductivity in Italy is one that could be characterized as "rejuvenating the old while adding the new." The funding of the finalized research project on conventional superconductivity will provide a good base for launching any new results from the small but well-coordinated fundamental research efforts scattered throughout the many pockets of excellence at Italian universities. The tight coupling of industry, especially the large Ansaldo Company, and the various superconducting electronics efforts should yield a quick response. Italy's superconductivity program will surprise many in both basic research and product development.

3/17/89

"Thin Films and Devices" Workshop Focuses UK Efforts in High Temperature Superconductivity

by Alan F. Clark.

In a small workshop held at the Ross Priory on Loch Lomond in October 1988, invitees from all of the UK's high temperature superconductivity efforts discussed recent progress and made several recommendations for future efforts. The discussion meeting on superconducting thin films and devices was sponsored by the two largest funders of superconductivity research, the Scientific and Engineering Research Council (SERC) and the Department of Trade and Industry (DTI), and was hosted by the University of Strathclyde at its small conference center on the shore of the beautiful Loch Lomond. Rainy weather, however, helped the 40 attendees from university, industry, and government laboratories focus on developing recommendations for future direction of the UK's superconductivity research programs in thin films.

Brief presentations summarizing research progress in making thin films of the new high T_c superconductors were given with adequate time to discuss the results, particularly with respect to their characterization. The University of Cambridge Materials Science Department, the University of Nottingham, the National Physical Laboratory (NPL), and the Royal Signals and Radar Establishment (RSRE) at Malvern have all made YBCO films using sputtering techniques. GEC-Hirst has also made BSCCO films using sputtering, laser ablation and organometallic techniques. Most of these are now working on *in situ* (i.e., no postdeposition annealing) techniques. Only the RSRE films show the sort of critical current expected of good epitaxial films, but NPL had not measured J_c for their best film, which showed the T_c and x-ray structure expected of epitaxial film.

Several new initiatives were reported to begin soon. These were:

- The SERC-supported laser ablation consortium of the Universities of Hull, Birmingham, and Oxford, University College, and Imperial College
- Two DTI supported industrial collaborative projects
- The Interdisciplinary Research Center at Cambridge (IRC) is investigating laser ablation and metal-oxide chemical vapor disposition (MOCVD).

There is also a new sputtering-based thin film and device application program at Nottingham and Strathclyde (with support from the IRC) which began in December 1988 and has attracted strong defense interest. There is as yet no work on specific thin film devices, but there is progress on device-related bulk work such as quantum interference devices (SQUID's), cavities, and antennae – especially at Birmingham University. Here, UK researchers are achieving results as good as anywhere else in the world.

Through extensive discussion several conclusions were drawn based on results achieved both in the UK and continental Europe. These were:

- A strong sputtering program, concentrating on *in situ* deposition, would be most likely to provide the high-quality films needed for both science studies and device development, and should be given high priority. Sputtering offers both versatility and low cost, but will probably require improved control and diagnostic equipment to realise its full potential.
- For devices, where in some cases very high-quality films are essential, evaporation techniques (using electron beam rather than thermal evaporation) may be needed in the long term to complement sputtering, and should be investigated.
- Laser ablation should be explored as a fast and flexible way of making films for test purposes, and possibly for small area devices.
- A method for reliable and accurate compositional analysis, preferably within the growth chamber, is urgently required (EDX and RBS are not sufficiently accurate).
- The MOCVD with its near variants is a promising technique, which could be very useful for the Bi and Tl compounds.
- The MBE, as conventionally understood, is too complex (e.g., UHV, liquid nitrogen shields) and insufficiently flexible for efficent high Tc use.
- More work is needed on substrate materials and preparation.
- Given that many devices may be operated at temperatures well below 77 K, for reasons of noise and sensitivity, there is still much useful work that can be done with YBCO which capitalizes on present accumulated experience.
- One or more groups could usefully diversify into using either Bi or Tl.

Based on the above conclusions it was recommended to the DTI and SERC that:

1. A sputtering program leading to the fabrication of Josephson junctions and thin film SQUID's is an extremely important component of the overall program and should be supported.
2. Because of its potential long-term importance to the program, the "modified MBE" program of Cambridge and Warwick should be awarded the funding necessary to modify the GEC MBE machine into an e-beam evaporation system.
3. A consortium of those interested (GEC, RSRE, Oxford, Nottingham) should seek to examine the best methods of obtaining accurate and reliable *in situ* compositional analysis.
4. The existing or proposed SERC-supported consortia – laser ablation, sputtering and evaporation – should be supplemented by a MOCVD consortium which could be based on the work by the IRC and Strathclyde (which already has substantial industrial funding for its MOCVD program), plus the groups supported for work on precursors.
5. The already strong links between the Ministry of Defense and work in universities should be encouraged and enhanced.
6. Priority areas for future work should include studies of:

- Influence of deposition and processing on epitaxy and on preferential a-axis, c-axis orientation
- Flux creep, flux pinning, and noise sources (especially 1/f)
- Processing and etching techniques
- Tunnel-junction barrier formation
- Multi-layer deposition (counterelectrodes for junctions, integrated structures such as flux transformers)
- Proximity effect physics
- RF losses, in both films and substrates.

It was further recommended that work on devices is essential, including those based on niobium, so as to continue to develop the enabling technologies. Otherwise, the UK may develop good processes, but the Japanese (and others) will be the only ones able to exploit the high Tc materials in instruments. The UK must be able to respond effectively to this challenge; an intense effort is needed, now, simply to catch up.

3/13/89

NEWS, NOTES, AND ABSTRACTS

The Use of Active Noise Control in Automobiles

Scientists and engineers of Topexpress Limited (Cambridge, UK) have recently demonstrated the use of active control to reduce automobile engine noise. On the occasion of the opening of the new Topexpress offices in Cambridge. Mr. Tony Newton, the Minister of State at the British Department of Trade and Industry, was reported to have driven a car fitted with an active control system that successfully reduced the engine noise by 10-15 dB.

The unwanted repetitive noise of the engines is monitored by a set of microphones inside the passenger compartment and the signals are fed to a microprocessor located in the trunk. Here cancelling signals are generated and then transmitted to loudspeakers which broadcast the out-of-phase sound back into the car thereby neutralizing the noise that would be sensed by passengers.

The principles of active control of noise have been available in the scientific literature for decades. What is currently of significance is the demonstration of the practical realization of such systems.

Topexpress and other groups within the UK working in this area have recently attracted much attention in the public press. The participation of Mr. Newton in such a demonstration has certainly added to the public's awareness of such technology.

Topexpress is the computer and scientific consultancy founded in 1978 by Professor Ffowcs-Williams, Rank Professor of Engineering at Cambridge University, and well known to the acoustic community.

David Feit
2/20/89

A Look at Euroscience

With 1992 quickly approaching, many in Europe are looking to the eventual free movement of people, goods, and services across the national boundaries of countries within the European Economic Community (EEC). When this occurs, the US must look at a cooperative Europe as a serious contender in the race for scientific and technological superiority.

Europe has seen many long and painful battles over territory and markets, but hopefully such warfare is relegated to history. The one arena in which presently there is keen competition is the world of science. In a recent issue of The Scientist, Volume 3, No. 1, January 9, 1989 an article written by David Pendlebury looked at this issue.

He found that although the UK puts out more scientific papers than any other country of the EEC, the articles from Switzerland carry more influence. Citing data compiled by the Hungarian Academy of Sciences, the UK clearly dominates in terms of volume of papers produced among the most significant journals of science. This is in a context, in which about 300,000 European articles were produced in 1988 in some 350 scientific journals surveyed.

The clout of each country's scientific output is measured in terms of a relative citation rate. This was calculated by comparing the actual number of citations per paper received by articles from each country to the average citation rate for the journals in which the paper was published. Using data for the years 1981-1985, Switzerland had a relative citation rate that exceeded 1.2; the Scandinavian countries, Denmark and Sweden, ranked between 1.10-1.19; while the UK, Belgium, the Netherlands, and West Germany were in the next level, 1.0-1.09. A ranking in a level exceeding 1.0 indicates a higher than expected citation rate, while one lower than that level shows lesser than expected performance. With regard to the actual output of published papers, the UK produced about 25 percent, followed by West Germany with 17 percent and France with 15 percent of the papers written by European scientists. Switzerland contributed close to four percent of the European output.

David Feit
2/2/89

INRUN to Develop a European Practical Nb3Sn Superconductor

In a primarily industry sponsored program, called INRUN, research teams in the United Kingdom have set about to develop a standard "workhorse" superconductor based on Nb3Sn technology. The objective is a cheaply produced, reliable, and widely accepted Nb(3)Sn conductor much as has been developed using NbTi for the highly successful magnetic resonance imaging (MRI) industry. INRUN, an acronym indicating Industry, Rutherford Laboratory, and Universities, includes researchers from Imperial Metals Industries, Oxford Magnet Technology, and National Standards from the industrial side, Rutherford Appleton Laboratory from the government, and Oxford, Cambridge, and Manchester Universities. This includes virtually all the best capabilities in Britain for developing a practical superconductor. The work is primarily supported by the industries involved with additional support from CERN, Rutherford, and the British government through its Department of Trade and Industry.

The conductor will use multifilamentary copper-niobium and the internal tin process with hydrostatic extrusion. The resulting practical conductor will have all the advantages of Nb(3)Sn for producing high critical currents at high magnetic fields and permit the next generation of superconducting magnets to be built as reliably and economocally as the MRI magnets of today. Applications for such a conductor capable of large current densities at fields well above 10 tesla are already in demand for nuclear magnetic resonance, high energy physics, medical systems, and fusion containment. The goal is to be able to bridge the gap presented by the conventional NbTi technology and the much anticipated revolution with the new high Tc superconductors which is admittedly pushing further and further into the future.

Alan F. Clark
2/6/89

ONREUR REPORTS AND MAS BULLETINS

Reports

To request reports, indicate the report number (in parentheses after the title and author's name) on the self-addressed mailer and return it to ONREUR.

Chemistry

Scales of Hydrogen Bonding Workshop, by M.H. Abraham. (**9-8-C**) About 25 chemists took part in the ONREUR-sponsored workshop, "Scales of Hydrogen-bonding," held in London from 1 through 3 July 1987. The purpose of the gathering was to discuss current activities in setting up scales of both solute and solvent hydrogen-bond strength. The importance of solute hydrogen-bond scales is the understanding and prediction of effects in such diverse areas as solubilities in water and in blood, water-solvent partition coefficients, toxicological studies, and the response of chemical microsensor coatings to vapors. Work on scales of solute hydrogen-bond acidity and basicity is well advanced. Most of these scales are based on log K values for hydrogen-bond complexation in dilute solution – that is, they are nearly always Gibbs energy related scales. Theoretical work by I.H. Hillier (University of Manchester, UK) has demonstrated that such scales are likely to be more easily handled than scales based on enthalpies of complexation. P.-C. Maria and J.-F. Gal (University of Nice, France) described their mutlivariate analysis that leads to an angle Θ decriptive of the elctrostatic: covalent ratio in the base: reference acid complex. M.H. Abraham (University of Surrey, UK) showed that it was possible to demonstrate the virtual equivalence of a solute scale and a solvent scale of hydrogen-bond basicity for nonassociated compounds, provided that the reference acids in each case led to Θ values that were almost the same – around 65 .

MAS Bulletins

The following Military Applications Summary (MAS) Bulletins were published between 17 March and 12 May 1989. The MAS Bulletin is an account of accomplishments in European naval research, development, test, and evaluation. Request copies of the Bulletins, by number, from ONREUR.

22-89	Data Bus Network Testing S2460
23-89	Foreign Weapons Evaluation (FWE) and NATO Comparative Test Programs (NATO CTP)
24-89	Lucas Turreted Tround Gun System
25-89	Jet Float
26-89	Stoneguard 2000 Erosion Resistant Film
27-89	Stereoscopic Vision System
28-89	PILOT – A Radar For Covert Operations
29-89	ASSETS – ASsessment System for European Technology and Science
30-89	DM 109 Underwater Acoustic Signal
31-89	HYDROBALL – An Expendable Current Profiling System
32-89	BSAP Fender System

THE EMBASSIES: TECHNOLOGY ROUNDUP

India

For further information on India items, contact Syed Ahmed Meer, Science Counselor, American Embassy, Shanti Path, Chanakyepuri 110021.

STRIDE: Cold Fusion Experiments in India. Since the cold fusion phenomenon was reported from the University of Utah in March 1989, Indian newspapers and television have been full of news about it. The Indira Gandhi Centre for Atomic Research (IGCAR) and the Tata Institute of Fundamental Research (TIFR) have reproduced the cold fusion experiment in their laboratories.

On April 15, TIFR was the first Indian laboratory to announce the demonstration of the cold fusion experiment. An enormous amount of heat was obtained by passing a minute current in a solution of heavy water. Dr. K. S. V. Santhanam, TIFR Chemical Physics Group, thought that no chemical reaction could conceivably release such quantities of heat.

On April 19, IGCAR, Kalpakkam, became the second Indian laboratory to report a successful cold fusion experiment. According to Dr. C. K. Mathews, Head, Radio Chemistry Program, IGCAR, the experiment involved the electrolysis of heavy water in a glass vessel using a titanium cathode and a platinum anode. Small amounts of nickel and palladium salts were added to the electrolyte solution. Because of background radiation, sensitive neutron detector measured more ejection of neutrons than could be explained.

In another set of experiments at IGCAR, researchers found that the temperature rise at the cathode was 3-4 times in heavy water compared to that in the light water, keeping all other factors constant.

However, IGCAR Director, Dr. C. V. Sundaram, told the press that the work at IGCAR was preliminary, that the experiment was not always reproducible, and that scientists at IGCAR were trying to standardize the conditions for the cold fusion.

Dr. P. K. Iyengar, Director, Bhabha Atomic Research Centre (BARC), stated that a similar but larger experiment will be conducted at BARC. The BARC experiment will be done in a much bigger electrolytic cell than used by the Utah team and large neutron detectors will be used to detect the neutrons from the fusion reaction. They expect to have results in about a month.

All of the three Indian laboratories now engaged in research on cold fusion are first rate and are known internationally for their outstanding research in nuclear physics. The claims of the Indian scientists on cold fusion definitely merit attention.

Brain Drain from India. A report on emigration from the Indian Institute of Technology in Madras (IITM) states that India suffers the emigration of more than 6,000 talented and highly qualified technical personnel per year to the United States, Canada, and Europe. Main sources for this flow of emigrants are the five Indian Institutes of Technology and the Indian Institute of Science at Bangalore. These six institutions are among the best Indian schools and enjoy a very good reputation in the English-speaking industrialized countries. The report estimates that more than 35 percent of all IITM graduates emigrate. Some disciplines, like computer science, are especially hard hit. Among the main reasons for the emigration are the inadequate working environment in India, and the intellectual challenge and high standard of living in the West. The report also lists a number of ways to stem the migration, mostly changes in Government of India policies.

The Department of Science and Technology recently sponsored an investigation of the extent of and the reasons for the emigration from the Indian Institute of Science at Madras. Much of the information reported here is taken from their internal report (Data Base for Brain Drain; Institution-based Study, DST 1989).

Percentage emigration per year from IITM of B.Tech graduates:
1966/72-20 percent 1973/77-22 percent
1978/82-27 percent 1983/87-35 percent

Percentage emigration per year by discipline*
Aerospace engineering-18.4 percent
Chemical engineering-44.6 percent
Civil engineering-18.8 percent
Computer science-58.5 percent
Electrical/electronic engineering-19.2 percent
Mechanical engineering-30.2 percent
Metallurgy-24.2 percent

*Computer science was introduced as a B.Tech discipline in 1982; therefore, only the graduates of 1986 and 1987 were considered.

Of the 429 people responded to the questionnaire (weighted sample), distribution by degree was: B.Tech 345, M.Tech 44, M.Sc. 12, Ph.D. 28.

170 stayed in India, 176 went abroad immediately after completing their studies at IITM, 14 went abroad but returned and are now working in India, 69 worked in India first for at least 6 months and now work abroad.

Current marital status: 53 percent of those who stayed in India, 49 percent of those who went abroad, 86 percent of those who came back, and 74 percent of those who worked here first and then left were married; 57 percent of those who left immediately were educated in a metropolitan area, but only 4 percent were educated in a village. Of those who stayed in India permanently 35 percent were educated in a village.

Educational background of parents: 62 percent of those staying in India had fathers with graduate or postgraduate degrees, 76 percent of those who emigrated had fathers with graduate or postgraduate degrees. The corresponding numbers for the education of the mothers are 19 percent and 32 percent, respectively. None of the immediate emigrants belongs the to scheduled castes or tribes.

The most important "pull" factors (weight) for those who left immediately:
Academic facilities-68
Spirit of fun and adventure-62
Career prospects-52

For those who returned to India after working abroad
Academic facilities-64
Spirit of fun and adventure-36
Career prospects-21

For those who worked in India first and then left
Career prospects-48
Spirit of fun and adventure-43
Financial benefits-42

The most important "push" factors were for those who left immediately:
Excessive bureaucracy-41
Poor career prospects-40
Emphasis on seniority for promotion-20

For those who returned to India after working abroad
Peer pressure-29
Poor career prospects-21
Emphasis on seniority for promotion-14
Family influence-14

For those who worked in India first and then left:
Poor career prospects-42
Excessive bureaucracy-32
Poor utilization of knowledge-29
Emphasis on seniority for promotion-29

The preceding figures are percentages.

Majorities of those who now work abroad or have worked abroad in the past find living conditions in India satisfactory, abroad excellent, working conditions in India satisfactory, abroad excellent. The same ranking holds for opportunities for individual growth, opportunities for professional advancement, and for recognition of merit.

Perceptions of emigration: Many of the respondents to the questionnaire commented on the quality and consequences of the emigration. The terms "brain drain' and "brain bank" were discussed. Most respondents consider the emigration as brain drain, both undesirable and unavoidable—a waste of national resources. A few people support the idea of a "brain bank" of highly trained Indians who could return to India and effect real technology transfer. Others see Indians amassing small fortunes in the West that can be returned and used to build new industries. Also mentioned is the benefits of the increasing political influence of the growing Indian lobby in the US.

How to counteract the emigration: The questionnaire contained several choices for the mitigation of emigration. The ones favored by the respondents were better financial rewards, better technical utilization of highly qualified people, and better working conditions in India. Some respondents believe that government restrictions on emigration, sound databases for those about to make the decision on leaving or staying, and international taxation may be useful. The majority of respondents clearly see that improvements must be made in India to stem the emigration. Information about educational and job opportunities in India should be given to those who have finished their Ph.D. abroad and are now facing the decision to return or not. Infrastructure improvements that are needed: transportation, telecommunication, power supply. Population control must be implemented with utmost seriousness. Government rules and regulations need to be liberalized. Free market mechanisms should be allowed to work. Promotions and incentives in academic institutions should be linked to merit and performance, and should not be linked to seniority, caste, or religion.

Many restrictive measures were proposed, including a compulsory national service in return for the free education, repayment of education cost by emigrants, a tax by the US and Canada on the income of Indian immigrants there.

Embassy comment: The data contained in the DST study of IIT Madras graduates parallels the study concerning IIT Bombay. It is also not inconsistent with the internal study done a year ago by the Consulate General in Madras, nor with paras 10-12 of the Embassy's report on the impact of immigration on US-Indian bilateral relations.

In discussions with the Science Counselor, the directors of several of India's foremost educational institutions pointed

with pride at the increasing percentage of their students migrating west. They take this clearly and justifiably as a measure of the quality of eduction at their schools. This is supported by the fact that the emigration from their institutions is very much larger than that from other, lesser schools; i.e., the selection of emigrants is positive for the target countries but quite negative for India in that the brightest leave. The same group of directors also admits that their best graduates have few challenging job offers in India. There are only about 1,000 industrial research and development laboratories in India, and many of those were set up as tax shelters. The rate of industrial innovation in India is very low. Government laboratories and universities are often very poorly equipped by Western standards and rarely have the kind of free and challenging atmosphere that these very bright and well-educated students are looking for. A large percentage of those engineering students who do not emigrate continue their studies at Indian schools of management or business administration, thus essentially leaving their technical careers. The Prime Minister and other insightful people have repeatedly and publicly criticized the Indian scientific establishment for the low quality of its work, for the low output, the lack of support for industry, its stifling atmosphere. In fact, even a recent spate of suicides among younger scientists was allegedly caused by the repressive atmosphere in government laboratories. Until either the job market in the West or the institutional culture in India change, this emigration is likely to continue.

Italy

For further information on Italian items, contact Mr. Gerald Whitman, Office of Science Counselor, American Embassy, APO New York 09794-9500.

Italy Technology Roundup Aerospace Industry. A commitment for 50 ARIANE/4 launch vehicles by ARIANESPACE for 1991 through 1999 will provide contracts to Italian aerospace companies SNIA/BPD and Aeritalia worth several billion lire. The SNIA/BPD will build 84 solid fuel boosters at approximately 2 billion lire each. Aeritalia is building 120 hydrazine tanks for the liquid fuel boosters at a value of about 110 billion lire.

Motorcycle Technology to Iran. The Italian motorcycle industry Gilera and the autocycle industry Piaggio sold to the Iranian government industry NMI technologies for the production of 100,000 motorcycles and 70,000 autocycles per year. The sale is estimated at 200 billion lire (about 148 million dollars). A preliminary protocol for sale of technology was also signed by Piaggio with the Soviet Union to produce 200,000 50 cc motors per year for autocycles.

President of Tecnopolis Resigns. The president of Tecnopolis, the largest research park in the south of Italy, resigned in March over a dispute with the newly elected administration board. The dispute concerned 135 billion lire (about 100 million dollars) in financing for research made available by the Italian government agency for the development of the south. But the board decided to revise the research programs because they had been devised three years ago and might have become technologically obsolete. Research projects would have involved industries like Fiat, Telettra, Olivetti, and IBM Italia.

Pirelli Installs CIM System for Tire Production. The tire manufacturer Pirelli has installed a computer integrated manufacturing (CIM) system in its Settimo Torinese factory that produces 21,000 tires per day. The CIM is used to automatically assemble all of the 10-12 components of a tire before the vulcanization stage. The Pirelli CIM, assembled by the Milan Tecav Company, employs a Hewlett-Packard 1000 system compatible with IBM and Digital expert systems. The system will be extended to other factories of the company. Total operational cost to Pirelli is 800 million lire (about 600,000 dollars).

Government Financing for Energy Research and Biotechnologies. The Italian Minister of Scientific Research announced that the new energy plan provides 1,520 billion lire (about 1.1 billion dollars) for new technologies research. About 203 billion lire will go to the National Hydrocarbons Agency (ENI), 230 billion to the National Electricity Agency (ENEL), 916 billion to the National Agency for Nuclear and Renewable Energies (ENEA), and 170 billion to other organizations. In addition, the Italian Minister of Agriculture announced the financing of 17 billion lire for research on advanced technologies and development of plant biotechnologies.

Electronic Cane for the Blind. Prof. Gian Piero Suarod, University of Turin, with the support of a firm that produces electromedical instruments, has created a "radar-cane" for the blind. The cane is equipped with sensors and an Olivetti computer and is capable of identifying obstacles, transmitting sounds or voice messages for reading traffic lights, tramway tracks, office entranceways, and writing on electronic screens posted in railway stations and airports. The cane was financed by the Lions Club of Turin, and will be marketed at a reasonable cost. The device will operate with rechargeable batteries with an 8-to-9 hour life and wil be no larger than a pack of cigarettes.

Robots are Short Sighted and the Market is Stagnant. During a meeting in Milan organized by the Italian Society of Industrial Robotics (SIRI), trends in the Italian robot industry were reviewed. The slowdown of robot sales was attributed to the small size of companies that have entered the market and to the lack of robots equipped with optical sensors. During the meeting, some Italian companies presented developments on robots with vision.

Camel Robot is producing robots with artificial vision for manufacturing automobile antidazzle headlights and the production of insulated electric cables. Sincon and Qomau companies presented their vision equipped robot employed in the assembling of wheels at Fiat's factory in Cassino.

Center for Liquid Crystals Research Established in Calabria. Calabria University under the sponsorship of the Italian University Consortium for the Physics of Matter has started a research program on new types of liquid crystals. The program focuses on those crystals that present a high electro-optical speed of molecular orientation one thousand times faster than that obtained in traditional liquid crystals. The studies point to the use of liquid crystals in displays for large screens and for extra thin TV sets, an area largely dominated by Japanese industry.

New Therapy for the Cancer of the Bladder. Prof. Giorgio Cavallo, the Institute of Microbiology, University of Turin, in cooperation with Prof. Giovanni Sesia, the Urological Department, the Turin Hospital "Molinette", have devised a new therapy for treatment of bladder cancer. The new therapy is called LATI – "Linfochine Activated Tumor Inhibition," and is based on the use of small doses of Interferon Gamma injected directly into the bladder. The therapy reduces the size of the tumor and prevents the formation of new tumors after surgery. The therapy seems to assist in preventing relapses.

CARSO Consortium Established in Trieste. The University of Trieste and the company Officine Galileo formed a consortium establishing a Center of Advanced Research for Space Optics – Centro de Ricerca Avanzata per l'Ottico Spaziale. The consortium will promote, coordinate, and develop scientific and technological research activities on components and optical instruments in the "XUV," "EUV" and "UV" bands for applications in space and on earth. President of the consortium is Prof. Roberto Stalio, Astronomy Department, University of Trieste, while the Director General is Eng. Guglielmo Cecchi, Officine Galileo. The consortium is located in the Trieste Research Area and hopes to cooperate with universities and research organizations.

Italy AIDS Update. As of March 31, 1989, there were 3,494 reported AIDS cases and 1,725 deaths in Italy (up 16.15 percent from December 31, 1988).

The Haemathology Division of the "Cervello" Hospital in Palermo, in cooperation with the Hygiene Institute of Palermo University, devised a new method that identifies within two days the presence of the AIDS virus through molecular biology techniques. The method is particularly useful in determining whether the disease has been transmitted between mother and infant.

The Italian Ministry of Health submitted to the government a plan for combatting AIDS for the period 1989-1991. The overall cost of the plan is estimated at 4,500 billion lire (about 3,300 billion dollars). It provides for an additional 15,000 hospital beds, 3,400 specialized physicians and 11,200 specialized nurses, sufficient to care for an estimated 15,000 AIDS patients and 235,000 serum-positive individuals by 1992.

The Italian Postal Service has issued a stamp dedicated to the fight against AIDS. The stamp shows a stylized image of the virus as seen through the microscope completed with the caption "Defend Yourself".

The Italian society of social psychiatry sponsored a meeting to discuss the legal aspects related to AIDS. For example: may a spouse obtain a divorce if the husband or wife becomes serum-positive? Can a serum-positive parent obtain custody of the children? If a serum-positive person is aware of his status may he be prosecuted if he knowingly infects other individuals?

A nurse who was contaminated in a Turin hospital in March 1987 by an exploding blood pressure monitor was awarded 700 million lire by the courts. In addition, the defective monitor's manufacturer and the ward's supervisory doctor each received a 6-month jail sentence.

Milan with the highest number of AIDS cases in Italy, is facing a shortage of beds in hospital infectious disease wards. The Association of Physicians of Milan is attempting to persuade the regional authorities to increase beds for AIDS patients.

The Italian Association of Blood Transfusion is requesting compensatory damages from the Ministry of Health, claiming that between 1981 and 1984, when AIDS tests for blood banks were not yet mandatory, about 39 percent of Italian hemophiliacs contracted AIDS from infected blood.

The Netherlands

For further information on this release, contact ODC Netherlands CDR Donald L. Dahl, Tel: 31-70-624911, ext. 312.

Alcatel. Alcatel is a leading European telecommunications company that is very involved in defense-related projects for both European and American customers. Alcatel Nederland is a subsidiary of Alcatel N.V. which was formed by the amalgamation of the telecommunication divisions of the ITT Corporation and Compagnie Generale d'Electricite (CGE) of France. Members of the Office of Defense Cooperation-Netherlands (ODC) recently visited Oldelft to learn more of their capabilities and to discuss the potential for cooperative projects.

In January 1987, the European telecommunications operations of ITT combined with CEG, as a joint venture, to form the largest telecommunications company of the European continent. The resulting organization, Alcatel N.V., is approximately 65 percent French-owned (CEG), 30 percent ITT-owned, with minor interests held by the Belgium Societe Generale and the Credit Lyonnais Bank of France. Worldwide, Alcatel is active in 110 countries, employs nearly 150,000 people, and had 1987 sales of approximately $11 billion.

Alcatel Nederland is a subsidiary of Alcatel N.V. with major activities in telephone switching systems and special interfaces, digital PABX with data handling capabilities, office automation and business systems, infantry fighting vehicle control systems, railway control and safety systems, cable TV control equipment, and customized electronics. Located within the Netherlands, Alcatel Nederland employs more than 1,100 people and generated $128 million in sales in 1987.

Alcatel's complexion as an electronic equipment supplier is changing in response to the restructuring of the European telecommunications market and to the privatizating of the Dutch PIT (the government controlled monopoly of communications). This is impacting Alcatel by creating more competition for the end-user equipment in this industry. In response, Alcatel is focusing increasingly on the aspect of the industry in what they have historically considered their core business, namely, centralized switching and control systems. Additionally, Alcatel N.V. is forming a corporate defense market policy that will be aimed at providing equipment to satisfy military infrastructure needs, high technology radio systems, and C3I applications, according to company representatives.

Alcatel Nederland continues to play a strong role in telecommunications. They manufacture a version of the advanced digital telephone exchange system 12, various customized PABX systems, and are involved in an experimental interactive cable television system with the Netherlands government in the southern Limburg region of the country. Other civil market, or infrastructure-related activities include remote diagnostics equipment, automatic dialing systems, remote activator systems, high voltage power supplies, railway safety equipment, and automotive and other customized electronics.

Alcatel Nederland is also a strong supplier to the defense market. A long-time supplier to the Netherlands' army and air force, Alcatel is also involved in several international cooperative projects. These projects and their international partner/customer include: M113 vehicle control equipment, BFV vehicle, turret & weapons control equipment with Ford Motor Company, MLRS vehicle control equipment with LIV, F-16 data transfer unit with Fairchild, Mark V vehicle control equipment and panels with Vickers, Stinger components with Dornier, and supplying spares to the US government for BFV, MLRS, and M113.

Alcatel Nederland's major manufacturing operations are located in The Hague, The Netherlands. Here they operate a semi-automated facility for small series production, with a great deal of flexibility for sophisticated electronics production. They presently have an AQAP-4 quality certificate; however, their representative indicated that they anticipate being upgraded to AQAP-1 levels in the near future. Their manufacturing capabilities include printed circuit board assembly of various types (including single, double, and multilayer boards, flex circuits, backpanels, solder mask,

press fit, wire wrap, and standard connectors). They are also capable of automated component sequencing and insertion in addition to surface mounted components. Alcatel also applies conformal coatings, including Paraleen, in a Class I clean room facility. Their factory is also equipped with US government-supplied environmental stress screening equipment for board and box level thermal shock/stress and vibration testing following assembly. Alcatel Nederland's representative indicated that this equipment is being utilized at less than one-half capacity by their current work load.

Both the international organization (Alcatel N.V.) and the national company of Alcatel Nederland are focusing on the defense market. They appear to be reliable, highly qualified suppliers in the electronic industry with an integrated engineering and manufacturing capability. Already involved with several US defense companies, they expressed an interest in increasing their involvement on cooperative projects in the future. They also indicated that this cooperation could take the form of either "build to print" work or earlier project development participation, with follow-on production. Alcatel is a company that merits full consideration as a European participating partner.

Fokker N.V. Fokker was founded in 1919 in the Netherlands and following World War II has emerged as the leader in the Netherlands aerospace industry. Additionally, Fokker is a well respected name in civil aviation, as evidenced by the strong sales of the Fokker 100. Members of the ODC Netherlands recently visited the Fokker facilities at Amsterdam's Schiphol Airport to learn more of their capabilities and to explore the potential for cooperative defense related projects.

Fokker has a long history of licensed military production. Noteworthy projects have included the F-104, NF-5, and the F-16 A/B. Additionally, Fokker is a strong participant in missile programs including Hawk, Nike, NATO Sea Sparrow, Stinger, and Patriot. Fokker also produces shelters and has delivered more than 3,500 to the Royal Netherlands Army and the electronics industry.

Fokker N.V., of the Koninklijke Nederlandse Vliegtuingenfabreik, is organized into four production companies and two primarily financial concerns. The latter include Avio-Diepen B.V., involved in aerospace products trading, and Aircraft Finance and Trading B.V., which deals primarily with used aircraft. The Fokker production companies include Fokker Aircraft and Components; Fokker Aircraft Services B.V., dealing in aircraft servicing and modification; Fokker Space & Systems B.V., involved in design, development, and assembly of satellites and other space hardware for the European Space Agency; and Fokker Special Products, the manufacturer of the containers, mentioned above; and other less complex components. All of these organizations are carefully coordinated by the parent company, Fokker N.V.

Fokker is a major participant in the F-16 A/B coproduction program. In addition to manufacturing several components for the F-16 A/B, Fokker also assembles and tests at their Schiphol facility. Presently, Fokker is producing approximately one F-16 A/B per month to meet delivery schedules extending into 1993. They also manufacture F-16 center wing sections that are used in the F-16 C/D assembly program AI GD, Fort Worth.

A major portion of the activity at Fokker's Schiphol plant is centered around the production of the Fokker 50 and Fokker 100 civil transportation aircraft. Sales and production of the latter are beginning to saturate the available facilities, although no impact on the F-16 program has been reported. Both of these programs continue Fokker's tradition of international cooperation with firms from at least six European countries supplying major components of these two aircraft.

Fokker remains a leader in the Dutch aerospace industry. Their reputation for quality production is well known and their participation in cooperative projects is a matter of course for their organization. Fokker also appears to be interested in continuing, if not increasing, their amount of participation with US defense industry. This view of Fokker should extend beyond the F-16 A/H coproduction and derivative aircraft development programs. The various production companies of the Fokker corporation offer strong expertise in their specialties and should not be overlooked. Members of this ODC plan to visit each of the production companies and will provide detailed reports on each.

Oldelft. Optische Industrie de Oude Delft, N.V., (Oldelft) is the parent company of an international group of companies specializing in the developing, producting, and selling of advanced optical, optronic, electronic, and precision mechanical equipment. Their products are targeted at medical imaging, robotic vision, laser rangefinding, thermal imaging and image-intensifier night vision. Members of the Office of Defense Cooperation-Netherlands recently visited Oldelft to learn more of their capabilities and to discuss the possibilities of cooperative projects.

Oldelft, a company more fifty years old and privately owned, is a self-acclaimed world leader in their fields of specialization. They employ more than 1,400 people worldwide and an annual turnover of approximately 200 million Dutch guilders (approximately 100 million US dollars). Company representatives stated that they invest between 10 and 15 percent of their sales revenue in research and development, allowing them to continually build upon their experience for the future.

Oldelft is truly an international company with manufacturing facilities located in the Netherlands, the Federal Republic of Germany, and Belgium. Other subsidiaries, specializing in sales and marketing, are located in the Far East and the United States, as well as in Europe.

Oldelft applies their specialties to a variety of defense related products-night vision equipment, thermal imaging equipment, laser apparatus, and equipment for detecting chemical agents. As a leading producer of image intensifying tubes, Oldelft produces a line of night vision equipment ranging from rifle scopes and binoculars to full day-night observation and aiming systems. Their thermal observation technology finds application in the "Orpheus" reconnaissance pod used for the RNLAF F-16 reconnaissance mission and in various tank observation and aiming systems. Combining laser technology with other optronics, Oldelft incorporates laser rangefinding into their tank observation system in addition to producing a portable laser rangefinder. These technologies are also used in their coproduction program for components of the F-16 A/B heads-up display system. Oldelft has also applied their expertise to chemical detection in their automatic chemical alarm, local system (ACAL). They claim earlier detection of chemical agents, with fewer false alarms, than can be provided by other systems. In providing these and other products, Oldelft has maintained an AQAP-1 quality certificate since 1973.

Oldelft's other product lines are included in the industrial and medical fields. Oldelft claims to have eliminated robotic blindness with their seampilot system which incorporates laser and optical technologies into sensing systems for robotic applications. Their medical related products are in three fields – X-ray diagnostics, radiotherapy, and ultrasound diagnostics.

Oldelft is a relatively small, highly specialized company with a good deal of experience in the international markets. They should not be overlooked when es-

tablishing cooperative defense programs. Oldelft's representatives expressed a preference to become involved in the development stage of programs rather than waiting until the "build to print" forms of coproduction that often occur.

Holec Nederland BV. Holec is the largest Dutch manufacturer of products in electrical power generation, distribution, and application. Target market segments include semi-government organizations, industries, and electrotechnical wholesalers. Military-related items in the Holec product line include main propulsion motors for submarines, uninterruptible power supplies, and numerous infrastructure items such as switchgear, motors, and control systems.

National Aerospace Laboratory (NLR). National Aerospace Laboratory conducts R&D in aeronautics and space technology under contract for civil, military, and international customers. The principal mission is to provide scientific support and technical assistance, on a nonprofit basis, to Dutch and foreign aerospace industries and organizations, civil and military aircraft operators, and governmental agencies concerned with aviation and spaceflight.

German Dutch Wind Tunnel (DNW). Construction, operation, and continued development of Europe's largest low speed wind tunnel are performed by the National Research Institutes of the Federal Republic of Germany (DFVLR) and the NLR The wind tunnel is located approximately a one hour drive from Amsterdam. The low speed wind tunnel at DNW is an atmospheric closed circuit tunnel in which aerodynamic and aeroacoustic measurements can be performed at reasonably high Reynolds numbers.

Interturbine Holland. Interturbine Holland is a member of the Interturbine Group of Companies, a worldwide group specializing in repair and metallurgical treatment of aerospace materials. The specialty is the repair of aircraft engine hot section components, including blades, vanes, combustor parts, turbine airseals, seal segments, and thrust augmentor parts. This company is the single source of repair for the EPG (Netherlands, Norway, Denmark, and Belgium) F-100 engine augmentors. Currently, the company repairs components from Rolls-Royce, General Electric, Pratt & Whitney, and Garrett turbine engines.

Eurometal N.V. Eurometal N.V. is a leading European producer of conventional ammunition. Their product line ranges from .50-inch through 203-mm ordnance and also includes mines and handgrenades. The company's major activities are focused on the larger caliber conventional ammunition (57-203 mm) and related components. Of particular note is Eurometal's production of the M483A1 155mm cargo round. They are the European leader of a consortium (which includes Great Britain and Italy) for this item. This successful arrangement is leading to a followon extended range round, the M864, and potentially includes Turkey in the consortium.

Groenpol Industrie Amsterdam B.V. Groenpol Industrie is a Dutch company specializing in the production and repair of power generation systems and the servicing of industrial electro-technical systems. The company is involved in several defense related projects including maintenance of the power systems at the AFCENT HQ facilities, integration and test of NATO Sea Sparrow, servicing of gas-turbine and no-break systems, and the production power supply systems for the Dutch Patriot air defense missile systems that are reported to have an extremely low infrared signature.

KLM Royal Dutch Airlines, Engineering and Maintenance Division. KLM's Engineering and Maintenance Division is located at Schiphol International Airport, near Amsterdam, The Netherlands where they employ more than 5,000 people. KLM provides maintenance and repair services for 21 airlines as part of a cooperative arrangement with the repair resources of SAS, Swissair, and UIA. KLM also conducts standard depot level maintenance of the Royal Dutch Navy's P-3 Orion aircraft.

Van Rieischoen & Houwens. Van Rieschoen & Houwens is a world leader in a wide variety of fields including electrical, electronic and computer engineering and state-of-the-art automation systems. Since 1860, the company has specialized in designing, manufacturing, and installing machinery, equipment, and complete systems onboard ships. The company's primary targets are industrial, mobile, marine, and offshore installations with automated systems and associated components specifically tailored to that installation.

Philips USFA B.V. A subsidiary of Philips N.V. located in Eindhoven, The Netherlands. Philips USFA was founded in 1949 for the development of electronic equipment for the Dutch armed forces. Presently, the company is one of Europe's leading suppliers of electro-optical and electronic defense products. Their product range includes passive night vision equipment, thermal imaging systems, secure communications equipment, closed-cycle cryogenic coolers, and special energy storage devices.

Spain

For further information on Spainish items, contact Mr. Ishmael Lara, Science Counselor, American Embassy, Madrid, APO NY 09285-8500.

Spanish Government Research and Development Policy. The Spanish government's research and development (R&D) policy is stated in its National Scientific and Technological Development Plan, which focuses on those areas deemed of most importance and seeks to pull together the disparate parts of government and private R&D in Spain. It hopes to have Spain catch up to the rest of the developed world by increasing its scientists' participation in national and international, particularly European, science and R&D projects and programs. Although unstated in the plan, government officials recognized that they must continue, or increase, the number of Spanish scientists who study and conduct research in the US.

The plan is administered by the Interministerial Commission for Science and Technology (Comision Interministerial de Ciencia y Tecnologia (CICYT) and the Center for Industrial Technological Development (Centro para el Desarrollo Tecnologico Industrial (CDTI). The CICYT, headed by the Minister of Education and Science, works with universities and institutions; the CDTI, headed by the Minister of Industry and Energy, concentrates in assisting private firms.

In March 1988, Prime Minister Felipe Gonzalez presented the government's 4-year (1988-1991) National Scientific and Technological Development Plan. Under the Science Plan, approximately $5.6 billion (revised figures) would be spent on science and technology in the 4-year period.

Forty-six percent of the $2.3 billion projected for national programs will go to R&D in production techniques; e.g., automation, robotics, and new materials, and for communications technology. Twenty-four percent will go to agriculture and natural resources, and 19 percent to quality of life; i.e., biotechnology, pharmaceuticals, Latin American social and cultural studies, and Spanish cultural and historical studies. Other minor programs include training researchers and work in high energy physics.

Even though it represents only 18 percent of the R&D budget, Spain's participation in international R&D projects and programs is an important aspect of the National Science Plan. Although Spain joined the Economic Community (EC) in January of 1986, when the EC was well into its first R&D program (1983-1987), Spain obtained what it considers acceptable economic returns from EC projects.

Spain is also part of the European consortium participating in the National Science Foundation's Ocean Drilling Program. In addition, the Spanish government has created the Science and Technology Development Program - Quincentennial ((Programa de Ciencia y Tecnologia para el Desarrollo - V Centenario) with the aim of reaching out to Latin America in science and technology as well as in the cultural and historical fields.

Many of Spain's science and R&D projects are channeled through the Higher Council for Scientific Research (Consejo Superior de Investigaciones Cientificas (CSIC). The international financing for the most part comes from UNESCO with local financing coming from CSIC or other Spanish government ministries or entities.

It is clear that the Spanish government intends to make science and technology and R&D a high priority item. The problem does not appear to be money, but the lack of Spanish scientists to spend it.

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